AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES May, 1960

How To Test Solid Motors With Ultrasonics...P 30

FISCAL FOOLISHNESS IN DEFENSE – LANPHIER . . . P 26

Water Makes The "Freedom Fighter" Hotter . . . P 42

Rocketdyne's Test Stands . . . P 17

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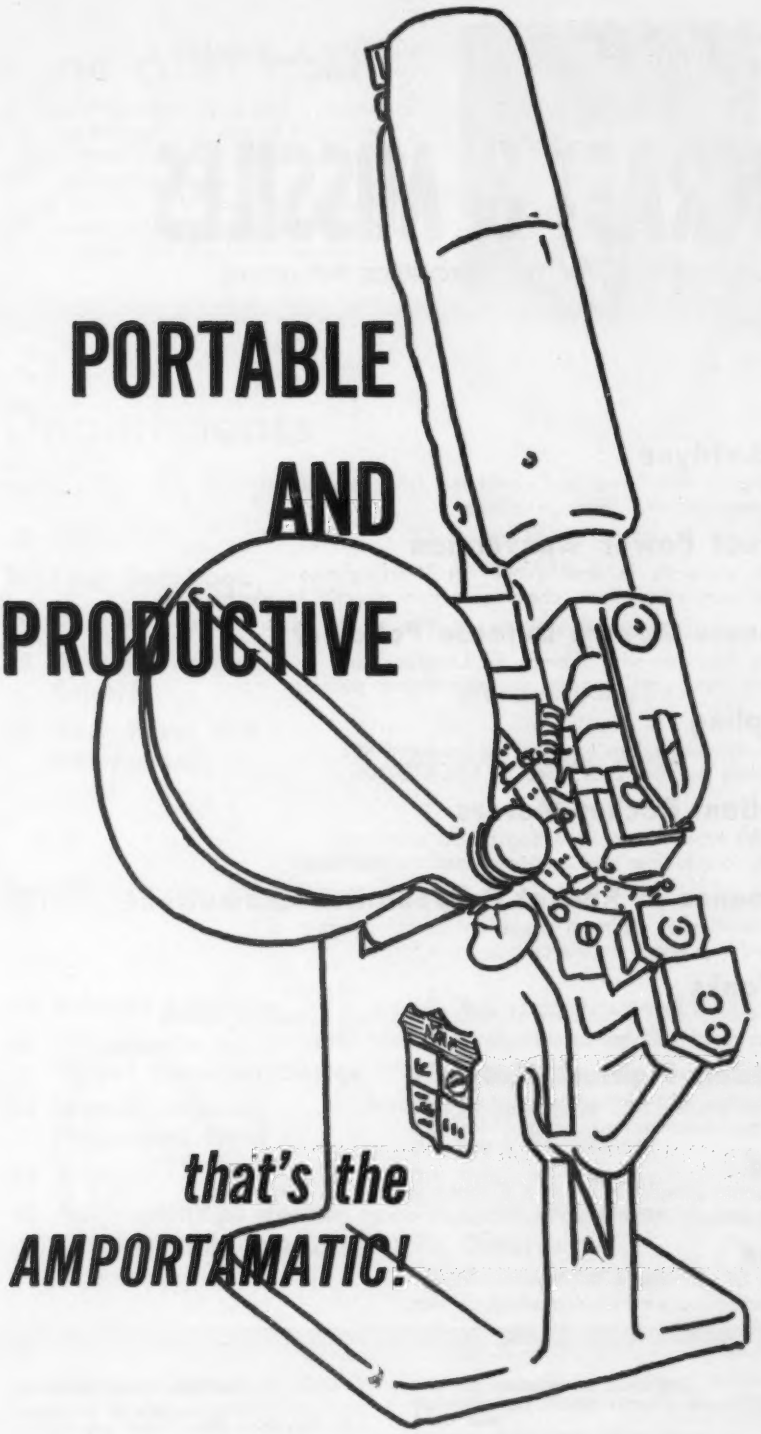

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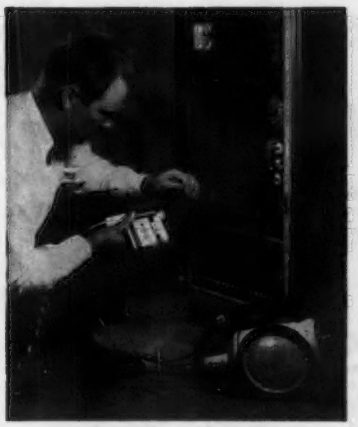

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May, 1960 *Volume 3, Number 5*

AIRCRAFT & MISSILES

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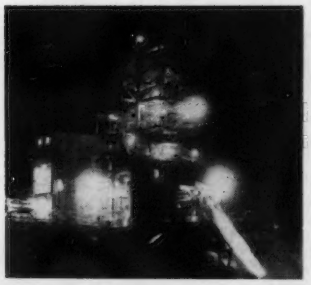
THE COVER STORY

Glaring structure of steel and concrete, on this month's cover, is one of Rocketdyne's test stands in the Santa Susana mountains. Massive, earth-bound harnesses for rocket power dot the 1700-acre Propulsion Field Lab, where Atlas, Thor, Jupiter and Redstone engines first flex their muscles.



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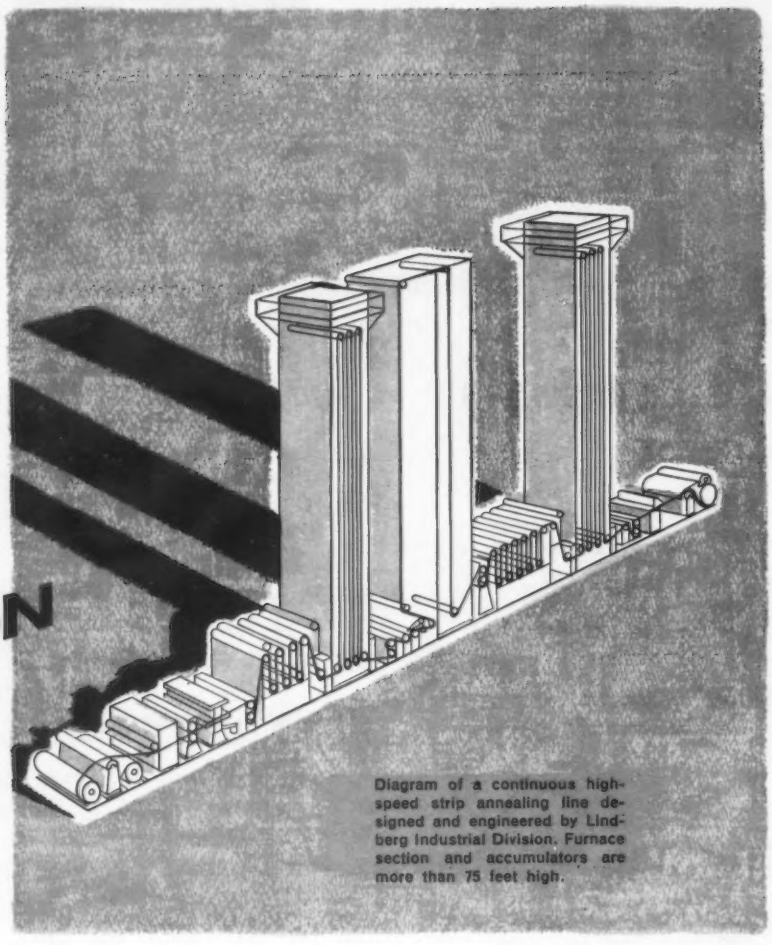

Diagram of a continuous high-speed strip annealing line designed and engineered by Lindberg Industrial Division. Furnace section and accumulators are more than 75 feet high.

We are more than the mere builders of equipment. Lindberg offers today a complete answer to any problem requiring the application of heat to industry. If you will give us your specific requirements for a part or a product, we will develop the right processes, design, engineer and install the equipment and facilities to fulfill satisfactorily your quality and product standards.

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- Complete plant layout and equipment for brazing honeycomb
- Foundations, roof, lighting, furnace installations for heat treating raw aluminum products
- A fully automated production line for heat treating plow shares
- Installation of two large ceramic kilns embodying a new concept of making high-refractory bricks
- Complete plant and automated production line for preparing, enameling and drying household ranges.

When you offer your industrial heating problems to Lindberg you get the combined skills of what we believe to be the country's finest group of engineers and technicians in the field, with many years experience in the solution of all types of "heat for industry" problems. Above all, since Lindberg provides a complete service, design, fabrication, installation, you depend on just one reliable source with the full responsibility for the satisfactory performance of your installation. So give your industrial heating problems to Lindberg. You'll be happy with the result.

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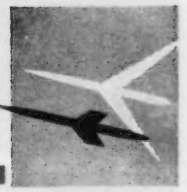


EDITORIAL

Can We Afford A Ban On "the Bomb"?

After a ban on nuclear testing, if agreed at Geneva, what next? A ban on nuclear warfare seems logical.

Sure, let's get rid of the big, somber cloud over the earth and outlaw the nuclear bomb. No one wants to live in constant fear. We don't want to train our children to run for the fallout shelter rather than the baseball field. I don't, anyway.

BUT, you and I should have a defense so strong, without "the bomb," that our freedom can be assured.

Do we have the military firepower and mobility, without the split atom, to stave off anything larger than a brushfire police action? How much of a conventional explosive can our present aircraft and missiles carry? Is our missile guidance effective enough to use conventional explosives and level military targets? Do we have the proper aircraft equipment to fight with conventional armament? Should we have cut back the B-70 program? The basic question is, can we afford to back up our Geneva program? Are we in a state of posture to accept a ban on the bomb?

These are questions which our political and military leaders have to ask themselves. Then the American people want to know the true answers.

For years, the military defense policy has been based on weapons using atomic capabilities. This is fine—as long as atomic war is being used as a bludgeon by certain powers. We should be able to clobber them at their own game. But, we also must be able to stay on top when these warlike powers want to play the other way.

I don't believe that a ban on the bomb should make us limit the development of prime movers for the warhead. We've been slipped the backhanded knife before.

Most of the current stockpile of bombs should be disposed of by directing their energy to some peaceful world goal. Initial atomic capability would then be extremely limited if any nation did break a ban agreement.

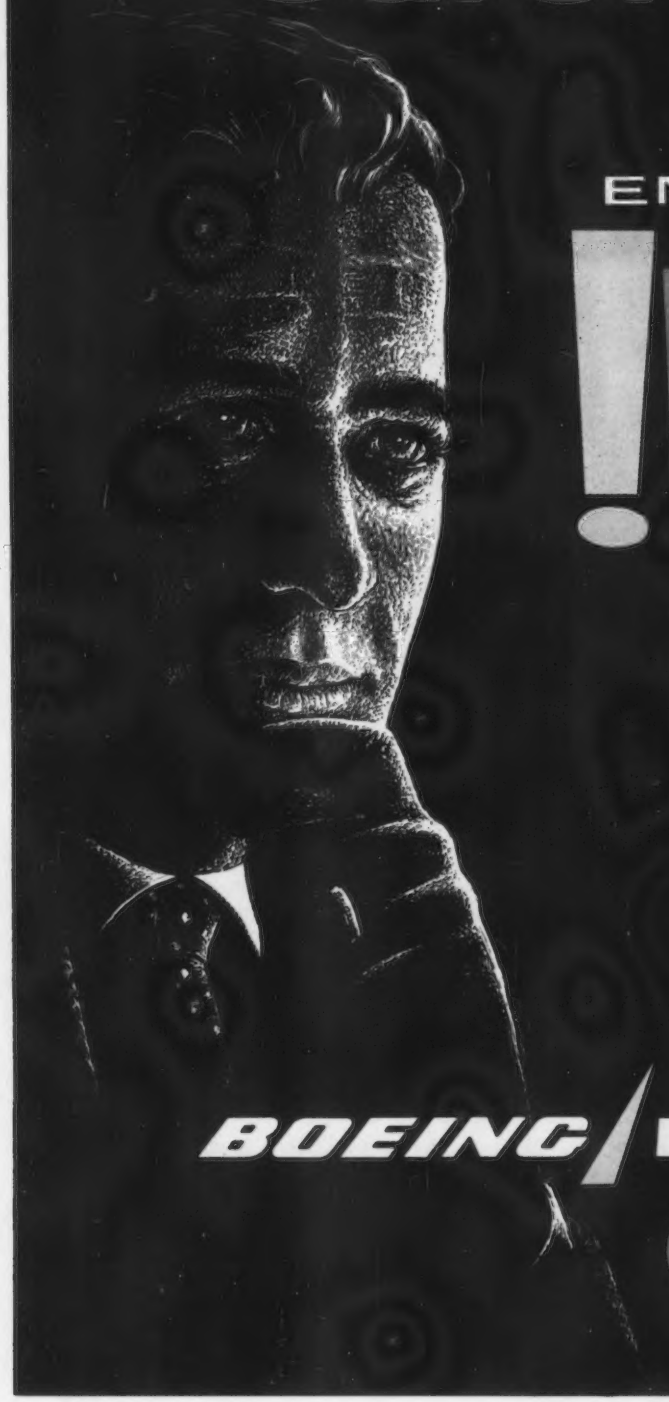
Before we do agree on the ban, we should have an honest evaluation of non-atomic capabilities.

Tom MacNew
Editor

...Consider Carefully!

This Opportunity for

SENIOR ENGINEERS



Making the RIGHT decision at the right TIME is the trademark of the serious engineer. His education and experience provide the background for making decisions that are right and timely.

Thoughtful men, with dynamic ideas, are finding their future at Boeing-Wichita, where the challenge of New Product Designs is stimulating their actions . . . and an expanding program offers greater variety and incentives for success.

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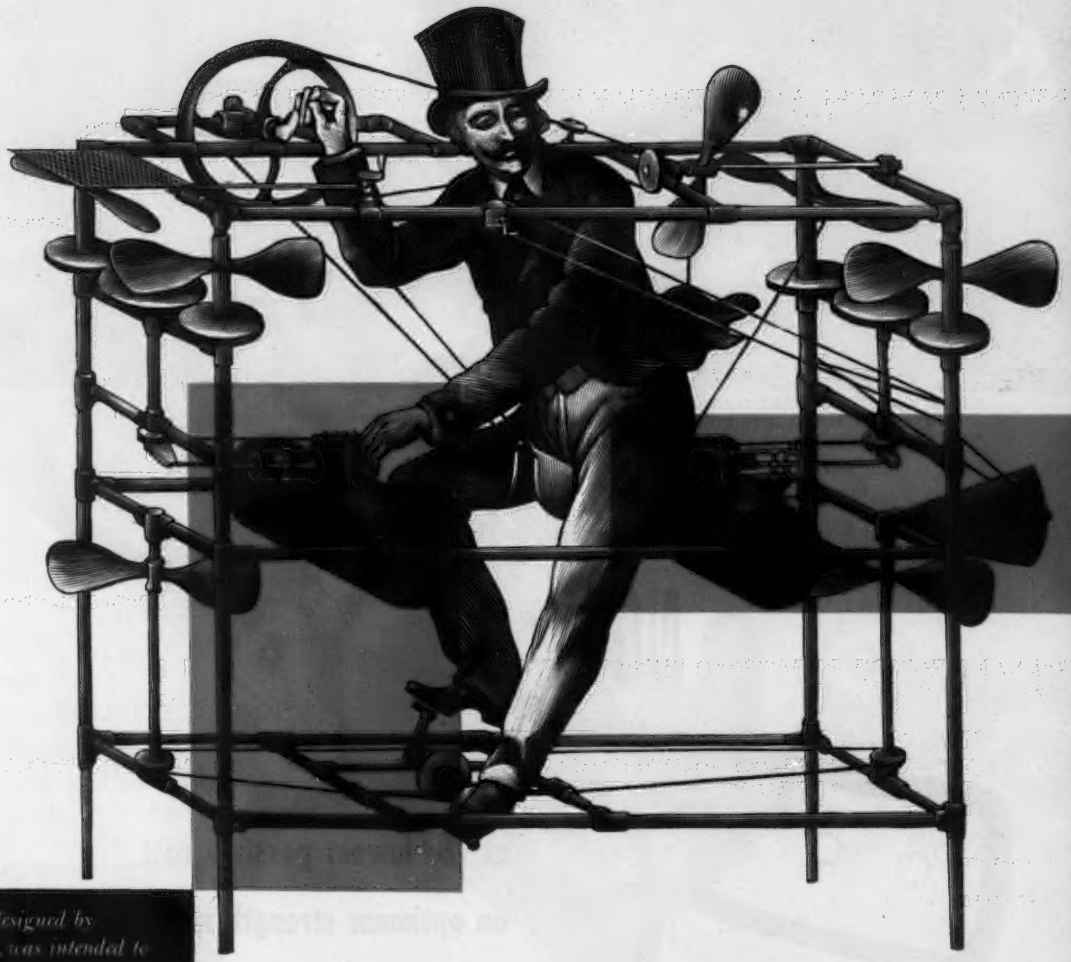

Ayres' Aerial Machine, designed by Dr. W. O. Ayres in 1885, was intended to get off the ground through compressed air generated by foot power. In this illustration of the machine, Brussel-Smith, noted graphic artist, has used his unique wood engraving technique to depict for this advertisement another of man's efforts to find the power necessary for sustained flight.

IMAGINATION IN SPACE

Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

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Data Capsule

SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

ATLAS "E" is expected to begin flight tests shortly. It would have greater range than Series D whose range is now reported well over 8000 statute miles.

NEW PROPULSION SYSTEM, Rocketdyne's MA-3, will power the "E." Engines are 100 pounds lighter than current ones, and produce about six per cent more thrust. Fiber-glass replaces metal bands around booster combustion chamber. Number of components is reduced 15 per cent by "bootstrapping," operating engine controls with fuel from missile instead of using pneumatic and hydraulic systems.

PLUG NOZZLE is being proposed for major space programs as a "middle way" between the clustered approach and the large single-chamber design.

TIROS II will reportedly include infrared gear for taking pictures in dark. Tiros I is sending pictures of cloud-cover over sunlit portions of Northern Hemisphere. Payload contains miniature TV cameras developed by RCA's Astro-Electronic Products Div.; is big advance over Vanguard II weather eye.

Development

SATURN BOOSTER flight test is slated for Summer of '61. Program is now concentrating on static tests of the booster's eight clustered H-1 engines.

TESTING AT 3000°F is being explored by Martin on brazed columbium sandwich panels. Panels are fabricated in new $40,000 brazing facility operating in Baltimore. Technique is aimed at putting columbium shingles on Dyna-Soar vehicles, which reportedly number 24 (dozen unmanned and dozen manned) in Air Force plans.

"CARCINOTRON," electronic countermeasure developed by France, is fitted to an aircraft, can reportedly jam radar, knock out missile homing heads.

MERCURY RETRO-ROCKETS use plastic nozzles, saving 2½ lb per rocket.

MERCURY TUMBLING is being simulated as far as possible with special rig at Lewis Research Center. Scientists there report that tumbling rates will probably be less than one or two rpm.

Production

FINAL LINK between Polaris producers and the fleet is now operating near Charleston, S. C. This is the "Polaris Missile Assembly Facility" of the Naval Weapons Annex. Missile components from contractors on both coasts will be shipped here for assembly, checkout and loading into nuclear subs.

"VIPER" rocket chambers are being produced at Ryan Aeronautical for Grand Central Rocket Co. The steel alloy rockets are 105 in. long, 6½ in. wide. They will propel Mach 2 test sleds.

MINUTEMAN first-stage engine transporters are now being produced at Cessna Aircraft. General Motors will produce the tractors and undercarriages. Bendix-Pacific will produce hydraulic systems for raising the container and lowering missile into silo.

"BUILDING BLOCK" family of missile igniters, destructors, and separators may be produced by Bulova R. & D. Labs.

FIRST ADVANCED FIREBEE, the Q-2C, has been produced at Ryan Aeronautical.

Procurement

POLARIS PROGRAM is on an extra-work-shift basis. The Navy has put an extra $36-million towards accelerated procurement of material and equipment for the missile. Another $16-million will speed work on nuclear subs.

BIG CUTS in Bomarc B program total over $300-million. Only eight bases will be built for the missile. Funds were reprogrammed to BMEWS, Minuteman, Samos, Discoverer, and Midas. Also, six Atlas bases will each have three additional missiles.

AIRCRAFT

Design

ORBITAL X-15 is being seriously considered. North American says vehicle would need more heat-resistant materials, plus system changes. Proposal sees X-15 as third stage of a large booster rocket. Reaction Motors says engine would use higher energy propellant than present one which gives about 60,000-lb thrust.

AIR FORCE REQUIREMENT for nuclear airplane called for a Mach 2-3 "dash" capability. Plane would reach this speed after releasing missiles.

BRISTOL 188 all-steel research craft will be equipped with a powerful new version of the de Havilland Gyron Junior. Producing 10,000 lb thrust, it is designed to operate beyond Mach 2.5. Installation will include a special reheat system. This ups engine thrust to 14,000 lb.

Development

IMPROVED B-58 may be developed by the Air Force. It would fly at top speed (1300 mph) all the time. Present B-58 flies at this speed for only a few hundred miles at a time.

KAMAN K-16B is undergoing tie-down tests with a rebuilt "rotorprop" and wing. In tests of propulsive rotor principle, ship will be air-freighted to Ames Wind tunnel next month--first flight may come this Fall. Kaman is also working on several adaptations of the principles of the Fairey Rotodyne.

TYPHON, Navy's new weapon system, will arm missile ships now being built. New radar techniques developed by Johns Hopkins Applied Physics Lab are key to system, operational in 1965-70. Westinghouse will produce the prototype radar. Typhon, smaller missile than Talos, will have short range anti-missile capability.

NUCLEAR ROCKET PROGRAM enters more advanced phase this Summer. "Kiwi-A-Prime" reactor, generally identical to previously-tested Kiwi-A, will start a long operation to determine failure point. "Kiwi-A3," also slated for test this Summer, will have simplified liquid-hydrogen system.

POINT ARGUELLO missile-launching base holds strong place in nation's future space plans. Surrounding hills will protect against noise and toxic fumes from boosters in 10-million-pound thrust class. Base is kept completely sanitized: no living, mess or recreation facilities.

ADVANCED R & D CENTER is beginning operation at Republic Aviation Technical staff has moved in; support equipment is being installed. One of first jobs will be pressure testing of "Stratolab II" gondola.

NUCLEAR TASK GROUP from Martin's Denver, Baltimore, Orlando, and Nuclear divisions is building up firm's capability in nuclear engine development.

MOVE TO CENTRALIZATION: Dr. Herbert F. York, Defense Department Director of research and engineering, now supervises U. S. missile launching sites, military space bases, radar tracking ranges.

Production

GROUND-EFFECT VEHICLE has been fabricated at Curtiss-Wright's South Bend Div. and delivered to the Army.

RADIANT-HEAT BRAZING MACHINE, to operate at Norair Div., Northrop Corp., uses banks of quartz lamps controlled electronically to program heat cycle. Prototype was recently unveiled. Production capability is estimated as 30 times that of existing luminous wall furnaces.

Procurement

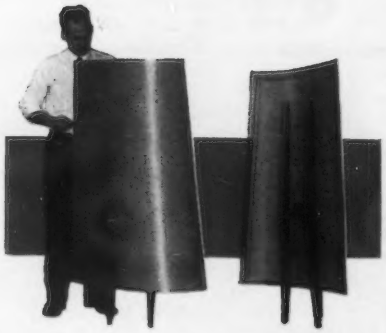
PHOTOSCAN aerial reconnaissance system has been purchased by the Navy and Air Force for competitive testing.

AERONCA designs, tools, produces and tests advanced brazed honeycomb structures

In the production of exotic high-temperature air weapon components, there is no substitute for actual experience. That is why Aeronca . . . with production records on several thousand brazed stainless steel honeycomb sandwich assemblies . . . is one of the recognized leaders in this highly specialized field.

And to meet the growing requirement for complex high-temperature structures, Aeronca has evolved a fully integrated facility for designing, tooling, producing and testing all types of brazed honeycomb sandwiches. This special facility includes more than 65,000 square feet of plant area and the most advanced production and inspection equipment available today. Brazed structures up to 14′ x 24′ can be produced in volume at present.

Whatever your requirements, Aeronca's experience and capabilities can assure you of uniform quality, on-schedule deliveries and the lowest over-all cost consistent with reliability and performance specifications. Our customers will verify that *Aeronca produces results . . . not claims!*



This complex speed brake for a new air weapon system illustrates Aeronca's advanced capabilities. Photo at top shows one of these units emerging from furnace after brazing cycle (indicated temp.: 2000°F.).

We have openings for creative R&D Engineers with Missile/Space experience. Write to Mr. O. E. Chandler, Mgr. Professional Employment

AERONCA manufacturing corporation
1726 Germantown Road • Middletown, Ohio

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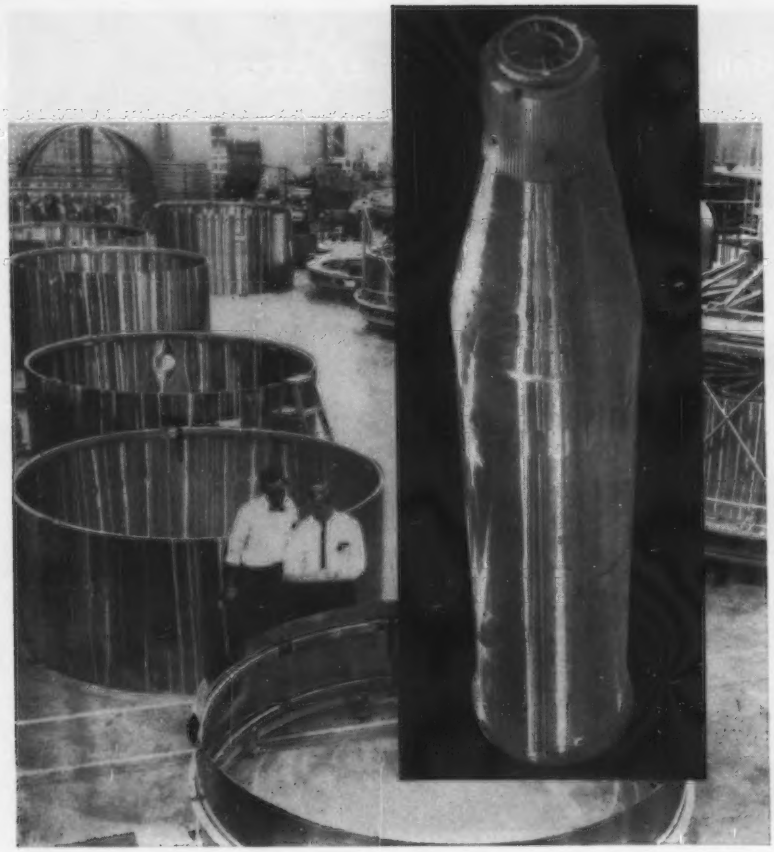

"the life of an ATLAS tank section begins in the town of Washington, Pa.

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May 3
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Society of Aerospace Materials and Process Engineers (SAMPE)
M.I.T., Cambridge, Mass.

May 2-5
National Flight Test Symposium
Instrument Society of America
San Diego, Calif.

May 9-11
Thirty-first Annual Meeting
Aerospace Medical Asso.
Americana Hotel, Miami Beach

May 9-12
Semi-annual Meeting and Astronautical Exposition
American Rocket Society
Ambassador Hotel, Los Angeles

May 9-13
Southwestern Metal Exposition and Congress
American Society for Metals
Sheraton Dallas Hotel, Dallas, Tex.

May 11-14
National Forum
American Helicopter Society
Sheraton Park Hotel, Washington

May 18-20
National Meeting
Society for Experimental Stress Analysis
Hotel Severin, Indianapolis, Ind.

May 23-26
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1960 Convention
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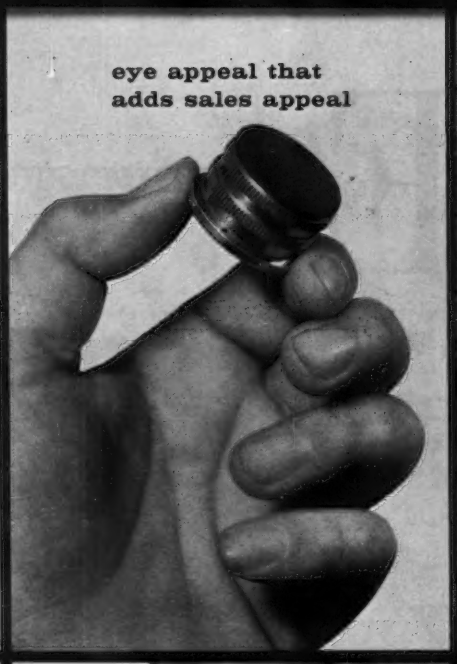

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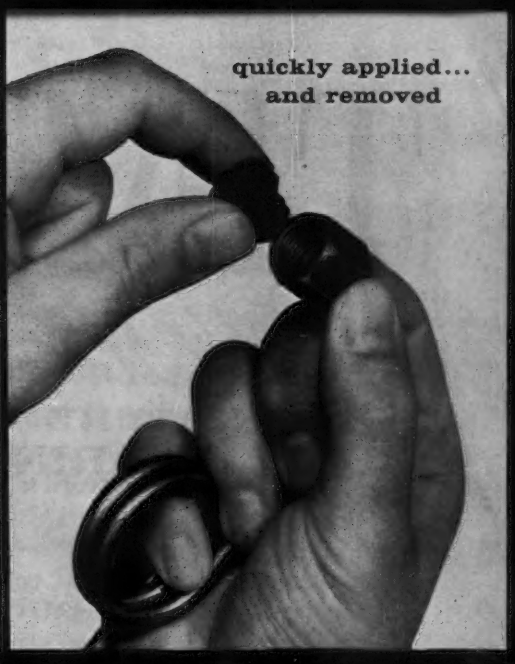

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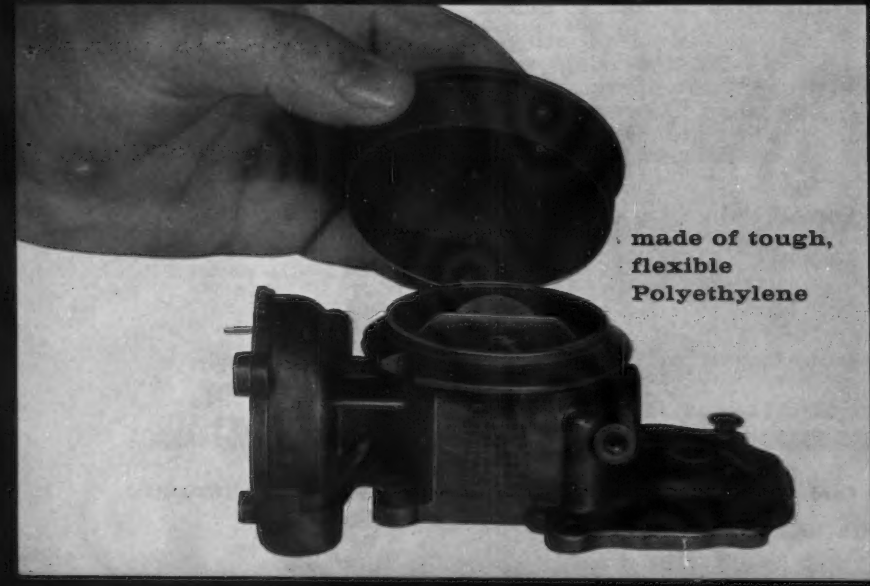

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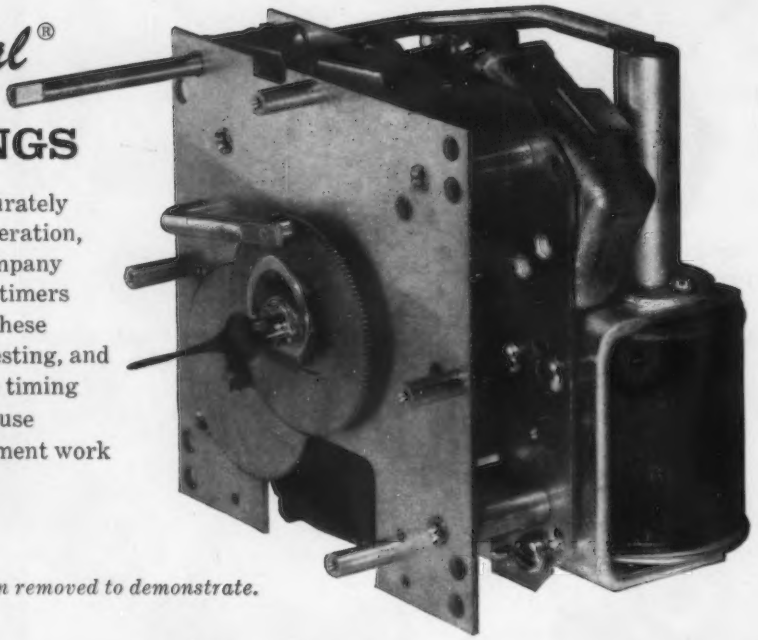
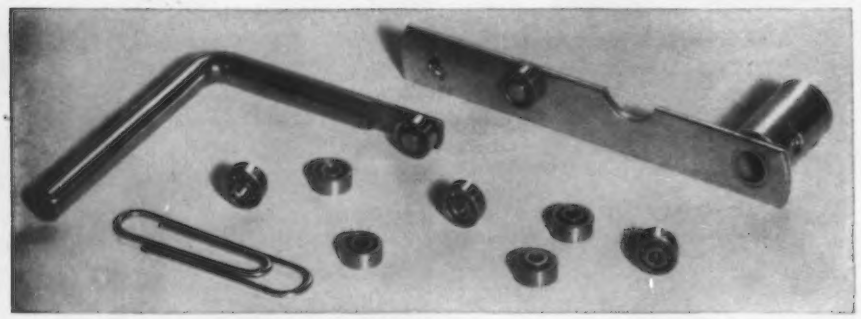


Dial and case have been removed to demonstrate.



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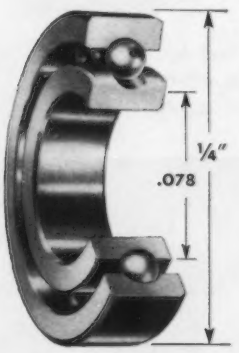

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TEST STANDS at ROCKETDYNE

Dynamic Design For "Static" Tests

Three-stand complex monitored and controlled from single nerve center; Sub-systems parallel those in missile

by Herbert R. Zweig,
Research Engineer
Rocketdyne Div. of NAA

Before a rocket engine can be trusted to take a missile aloft it must demonstrate reliability on the ground. Reliability means lots of testing, and requires a lot of test-stand facilities. These facts have become more and more apparent since U. S.'s modest beginning in modern rocketry with the MX-770 Navaho project.

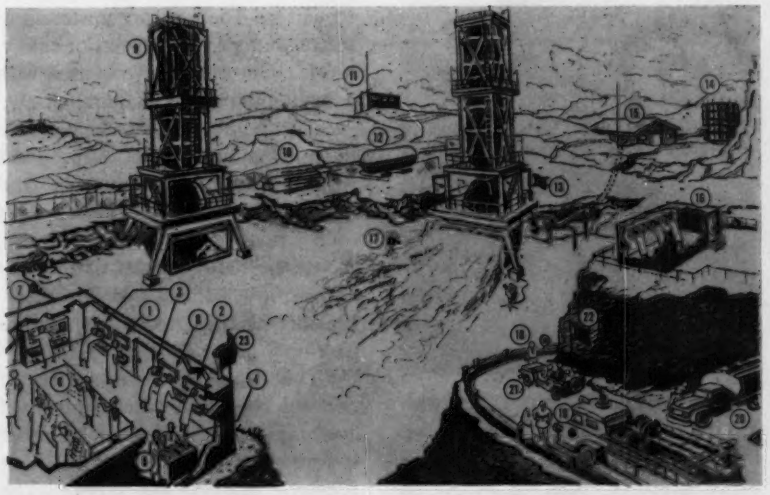
As the Navaho powerplant grew-up to 75,000 lb thrust and found use in Army's ballistic missile, producer Rocketdyne's testing facilities also grew up . . . with plenty of growing pains. They have grown to a formidable 19-stand complex at Santa Susana, Calif., manned by 2600 rocket specialists. Rocketdyne is now taking its next giant step—a test stand for the 1.5 million lb thrust F-1 engine, at Edwards AFB. Aerojet's Actron Div. designed the big stand.

A rapid engineering evolution has solved problems in stress, ground erosion, and test-stand instrumentation. The first stand (VTS-1) was built 100 ft high, to place the engine 75 ft above ground level and thus combat ground erosion from the rocket exhaust. This was fine for 60,000 lb of thrust. But engines grew, and this kind of stand created as many problems as it solved. Low-level towers now incorporate a water-cooled thrust deflector to combat erosion. This deflector is almost a design standard.

The magnitude of instrumentation growth at test stands can be imagined by considering that only 65 performance parameters per test were monitored in 1951; today, 456 are monitored. New facilities are built in a 3-tower complex. One block house and one crew can operate and monitor any one of the three stands. This concept has also become a design standard.

Stand Structure—Foundation of the test stand is supported by 25-ft

1. Engine Console Operator
2. Test Stand Console Operator
3. Qualified Observer (Can stop run: field glasses)
4. Senior Engineer in Charge of Test
5. Oscillograph Operator
6. Instrument Crew, Observers and Red-Line Men
7. Instrument Crew from Other Stand
8. Photographer, Remote Camera Operation
9. Test Stand No. 2, Temporarily Evacuated During Firing of Stand No. 1
10. High-Pressure N_2 Supply
11. Observation Post, 2 Qualified Observers Can Stop Run
12. Lox Storage
13. Red Flag & Light Signals
14. Water
15. Pump House, 2 Operators
16. Visitors on Hill Behind, Protective Abutment
17. Typical Movie Camera Positions
18. Police Officer Blocks Traffic
19. Emergency Fire Crew
20. Fuel Truck Waits to Secure
21. Operations Crew Withdrawn from Other Stand (8 Men)
22. Red Flag
23. Red Flag & Light Signals



TYPICAL TEST STAND complex at Rocketdyne is shown in part. Three test stands usually share one control center.

Water-cooled flame deflector uses 10,000 gallons H_2O per min.

deep, spiral reinforced concrete columns. The foundation, in turn, supports the flame deflector grid and the four main stand columns.

Each column base consists of a steel plate 3-in. thick and three feet square, it is anchored by 8 high tensile-strength bolts.

The flame deflector supporting grid consists of (13) 14 WF 136 beams, sloped at 45 deg. The overall length of the grid is 19 ft, the width, center to center of the outside beams, is 10 ft.

The stand foundation, per se, is reinforced concrete approximately 5-ft thick. The main columns of the stand are 24 x 24 in. box type of ⅞ in. plate steel. The columns rise to 27 ft to the first deck. The main structure of the first deck, at roadway level consists of 33 WF 200 beams. The columns rise another 20 ft and complete a rigid bent, with 24 x 24 x 1-in. "I" beams (the second deck).

LOW-LEVEL STAND copes with ground erosion from rocket blast by incorporating a water-cooled thrust deflector. Stand is supported by 25-ft deep reinforced concrete columns.

Fuel System—Most engine systems use RP-1, a petroleum-derived fuel similar to kerosene. It is delivered to the test sites by truck, and deposited in centrally located storage areas. The storage sites usually supply fuel to two test areas each having three large engine test stands.

Fuel is pumped 1000 ft from the storage area to the test stand, 100 ft higher in elevation. Supply line has a 4-in. diam, and the centrifugal pump has 20 h.p. Following an engine test, excess fuel is fed back to the storage area under gravity head.

Test stand fuel tanks are AISI 300 series stainless steel with capacities ranging from 3000 to 10,000 gallons. They are coded pressure vessels, rated up to 160 psi.

During a test firing the fuel tank may deliver 1540 GPM, (180 lb/sec) of fuel to the turbopump of a typical engine. To provide the turbopump with the required positive suction pressure, the fuel tank is continuously pressurized to about 80 psi by gaseous N_2. The pressurant is supplied to the tank via 2-in. schedule 160, stainless steel pipe, and a dome loaded pressure regulator. The pressure upstream of the regulator is 2450 psi. For safety, a 6-in. vent relief valve is used with a burst diaphragm in parallel.

The fuel run from the tank to the engine consists of 6-in. ducts with the following controls and measuring devices: Two pre-valves (one situated just below the tank, the other just upstream of the turbopump), a turbine type flowmeter, pressure pick-up, and a temperature pick-up (thermocouple).

The pre-valve is a device of convenience since the control of flow into the combustion chamber is performed by a valve in the high pressure side of the pump. The pre-valves may remain open continuously unless the fuel supply must be shut off for engine dismounting or for emergency situation such as fire. Fuel for the gas generator is tapped from the high pressure side of the turbopump.

Oxidizer System — Thor, Jupiter, and Atlas utilize liquid oxygen. It boils at −298°F and is stored in vacuum insulated vessels with capacities of 3×10^6 standard ft^3. The liquid oxygen is transported to the test site in vacuum-insulated trailer trucks.

From the storage vessel, the liquid is transferred to the run tank on the test stand. The transfer operation consists of circulating the liquid through a transfer pump (centrifugal) until it is chilled. Once boil-off ceases, the pump is turned on and the liquid passes to the stand tank. Further chill down of the complete transfer system must be affected before a liquid level can be established in the run tank. Transfer lines must retain their ductility at −298°F. They are austenitic stainless steel with a pressure rating of 150 psi at 100°F. The liquid oxygen tank capacities range from 3000 to 14,000 gallons. (See Flexible Hose—A Status Report, A&M July, 1959).

The liquid oxygen feed line from the tank to the engine is usually 11 in. stainless steel ducting and contains the following controls and measuring instruments: a pre-valve, pressure transducer, thermocouple and a turbine type flowmeter.

The pre-valve in the oxidizer system has functions similar to the fuel pre-valves, i.e., secondary control, where main on-off control is performed by the valve in the high pressure side of the turbopump.

The liquid oxygen is pressurized to about 80 psi with dry nitrogen to insure proper suction head to the turbopump. For safety there is vent-relief valve atop the tank in parallel with a burst diaphragm rated at the maximum tank operating pressure. Liquid oxygen for the gas generator comes from the high pressure side of the turbopump.

Where other oxidizers are used, the same systems may be employed

DATA COLLECTION CENTER is vast complex of recorders. Multipoint temperature printers and, circular chart recorders are used to record data with slow change-rates. Oscillographs, and other electronic devices are used where data change-rate is rapid.

CONTROL CONSOLE for fuel and lox is part of stand structure and is used during prefiring checkout. Safety record at Rocketdyne is good.

with the possible elimination of the vacuum insulated storage vessels.

Inert Gas Systems—The pressurization of the propellant tank, the actuation of valves and the purging of propellant piping require great amounts of N_2. It is stored in bottled banks at 3000 psi.

The bottle bank is supplied with gaseous nitrogen (GN_2) from a centrally located cascade system. In this system, liquid nitrogen is cascaded from a vacuum insulated storage vessel through an axial piston pump, where the pressure is raised to as high as 6000 psi. The high pressure liquid is then vaporized, and the gas flows to the storage bottles in the test area. GN_2 is required for various uses on the test stand at different pressures. These uses are tabulated:

- Propellant tank pressurization .. 2450 psi
- Low pressure valve actuation . 150 psi
- High pressure valve actuation 750-1500 psi
- Engine purge .. 750 psi
- General purging 10-50 psi

The bottle bank pressure is reduced to use pressure by regulating valves.

In order that the number of regulators be minimized, a console containing perhaps 10 of these valves, each having different pressure output ranges, is set between the bottle bank and test stand. The distribution of GN_2 is thereby systemized.

Water System — Flame deflectors require a water flow of 10,000 GPM to provide a film cooled surface. The average firing duration is 20 sec, and the average test frequency is one-half test per day per stand per shift. Since each test area includes three test stands, the total number of firings is one and one-half per day on a single work shift basis. If 20 sec is added to the firing time for pre-test and post-test water flow, the average daily water usage for deflectors per test area is 10,000 gallons. Water is also used in the fire fighting systems, for personal, and miscellaneous reasons.

Water is stored in tanks located on hills which rise some 400 ft above the test stands. The main water line from the storage tanks to the stand has a 24-in. diam and runs about 3000 ft.

Hydraulic System — High pressure hydraulic oil is required for certain valve actuation, engine gimballing, etc. The normal test stand uses oil at 3000 psi at a rate of 3 GPM. Usage may run as high as 30 GPM. The oil is supplied from and recirculated through, a pumping station consisting of a self-compensating axial piston pump, and a 100-gallon reservoir which serves as a heat sink.

The test stand, then, is a confluence of subsystems; the major ones being the fuel and oxidizer systems, and the support systems of pressurizing gas, hydraulics, and water supply.

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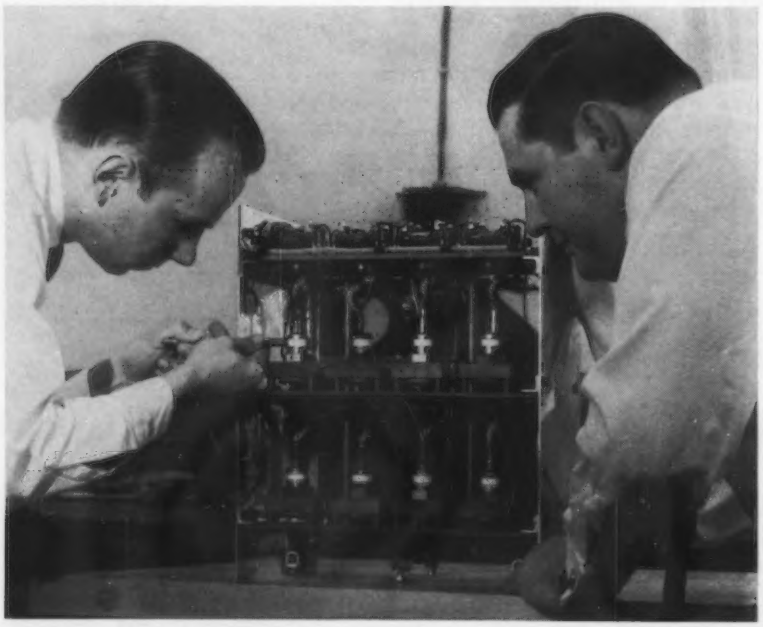
Perspective on Direct Power Conversion

Westinghouse sharpens focus on converting heat, chemical action directly to electricity. Materials development will pace progress

by S. Peter Kaprielyan

A symbolically novel groundbreaking ceremony took place recently in Pittsburgh. Dr. J. A. Hutcheson, vice-president engineering of Westinghouse used thermoelectric power to start the digging for a lab to be erected soon in Churchill Borough.

When complete, in 1961, the facility will help centralize research on methods to convert fuels directly into electricity. The thermoelectric generator used in ground breaking represents one such method. With their lack of mechanical components and inherent simplicity, direct conversion methods offer attractive possibilities as reliable and highly-efficient systems for future ground and airborne applications.



STATIC POWER—INVERTER developed by Westinghouse, converts a.c. output of direct power-generators into d.c. This 15 kilovolt-ampere system uses eight Trinistor semi-conductor switching devices.

Working lab models of power generators were shown at this occasion; a brief discussion of these systems follows.

Thermoelectricity—Basically, in a uniformly heated pellet of thermoelectric material positive and negative electrical charges are uniformly distributed. But, when heat is applied to one surface this distribution is no longer uniform; although the positively charged ions in the crystals remain fixed, the negatively charged electrons tend to move to the cooler end. Result is an electrical-charge gradient and a potential difference between the hot and cold ends which can cause current flow in an external load. Thermoelectric devices are arranged in series-connected thermocouples so their voltages are additive.

Growth of thermoelectric technology depends on our ability to adjust the number of free electrons in semiconductor materials. This is because: (1) the output voltage of any thermoelectric material is inversely proportional to number of free electrons; (2) the conductivity of material is directly proportional to number of free electrons. Thus, insulators with 10^{10} electrons/cm^3 generate Seebeck (output) voltages about 10,000 microvolts per ^{0}C difference between hot and cold ends;

to offset this, they have very high internal resistance. Metals give Seebeck voltages of about 5 microvolts per degree but have extremely low internal resistance. To obtain maximum power output or optimum efficiency from a thermoelectric material electron density is adjusted for an acceptable compromise value between high voltage and high electrical conductivity.

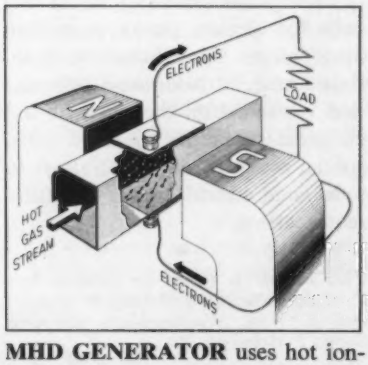
In actual generators several different thermoelectric materials are used to take advantage of fact that each has its best range of operating temperatures. Up to 600°C some semiconductors have proved satisfactory; to go up to 1000°C, certain insulator materials are used which have been modified into good thermoelectric materials. For example, pure nickel oxide is normally an insulator, but when modified by adding three per cent lithium, its resistivity decreases to about 0.01 ohm centimeters. Explanation is, in normal nickel oxide, nickel has a valence of plus two but lithium addition causes the appearance of nickel with valence of plus one. The material's greatly increased conductivity is brought about by an exchange of charges between plus-one nickel and plus-two nickel. It is through similar modifications that other materials are being developed for use at higher temperatures. For example, this approach led to one of the newest mixed-valence materials, samarium sulphide, which has a good figure or merit up to 1100°C.

Other problems include: (1) joining of thermoelectric materials with minimum contact resistance; (2) shielding from air to prevent corrosion; (3) mounting of devices so as to withstand shock and vibration.

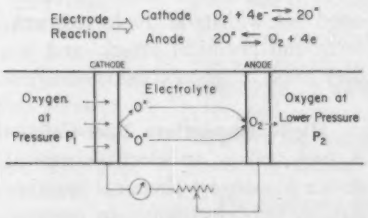
In one of the first generators built by Westinghouse for the Rome Air Development Center, 100 watts are produced from a 50-lb unit, cooled by free convection, for a power-to-weight index of two-to-one. Forced convection of air or water, to reject heat, may produce 15 watts/lb of weight for a power-to-weight index comparable to that for a typical, gasoline-powered 500-watt generator. Thermoelectric materials available today are capable of an efficiency of about 17 per cent but when assembled as elements of complete generators, over-all efficiency drops to about 6 per cent. Much of this loss is due to stack losses represented by the discharge of heat-bearing gases from the generator's "chimney" and the fact that some of the energy transferred through the walls of the chimney passes around but not through the thermoelectric elements. Experts foresee that as new materials are developed, probably in about five years thermoelectric generators with an efficiency of 30 per cent will become a reality.

THERMIONIC POWER — GENERATOR is demonstrated by Dr. J. W. Coltman, manager of electronics and nuclear physics dept. Westinghouse research lab. A glowing wire, within tube, emits electrons and causes current to flow in ionized cesium gas. Cesium capsule is at base of tube. Dr. Coltman foresees applications of device to power generation in space.

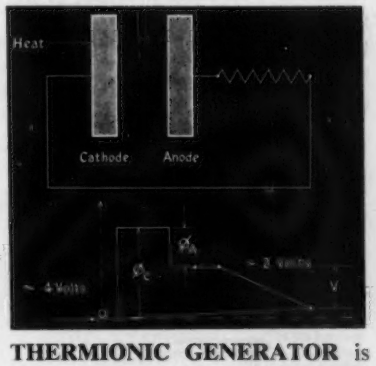
Magnetohydrodynamic generators — Magnetohydrodynamics (MHD), as a branch of physics in-



MHD GENERATOR uses hot ionized gas flow through a magnetic field; electrons in gas are deflected to anode. Electricity is produced as electrons move from the anode, through the load, to the cathode and back to gas stream.



FUEL CELL converts chemical reaction directly into electricity. It consists of an electrolyte which conducts an electric charge in the form of oxygen ions but is an insulator to electrons. The electrolyte is sandwiched between two electrodes. A voltage is created across the electrode-electrolyte sandwich when the oxygen is at different concentrations at the two electrodes.



THERMIONIC GENERATOR is shown in simple diagram, with an underlying plot of potential energy of the electron. Potential inside cathode is taken as zero. Θ_c is potential barrier at surface of metal; Θ_A is anode work-function.

Fuel-cell electrolite conducts oxygen ions but acts as insulator against electrons

volves both electromagnetic and fluid-dynamic phenomena. Practical realization of MHD power generation presently depend on the use of a conducting gas. For the gas to be conducting, free electrons must be present, along with an equal number of ions, plus a main body of un-ionized gas. Most direct approach to partially ionize a gas, and thereby make it conducting, is to heat it. However, the temperatures involved are beyond the limits of even the most modern of materials.

When the gas is "seeded" with potassium or cesium, adequate electrical conductivity can be realized at 4000 to 5000°F. The possibility of MHD generation, as currently conceived, hinges on the small region of overlap between the temperatures that a few materials are able to tolerate, and the temperatures which are necessary, even with seeding, to obtain adequate conductivity.

In an MHD generator, hot ionized gas travels through a magnetic field which is applied at right angles to the flow, and past electrodes which are in contact with the stream of gas. Electrons in the gas are deflected by the field and, between collisions with other particles in the gas, they make their way diagonally to one of the electrodes. An electric current is produced as the electrons move from the anode, through the load, to the cathode, and back again to the gas stream. Terminal voltage is directly proportional to: intensity of magnetic field; velocity of gas; and distance between electrodes. A generator will supply maximum power when the load connected to its terminals has a voltage drop equal to one-half of the circuit voltage.

Near peak power, efficiency of MHD generator may be as low as 50 per cent, because of I^2R losses. But efficiencies 80 to 90 per cent are possible when generator is operated somewhat below maximum power. This corresponds to the efficiency of a conventional steam turbine-generator combination, which is about 80 per cent.

Further progress in MHD engineering requires further studies on conduction of electricity in gases, and a better understanding of basic mechanisms of energy and momentum exchange in MHD generator. Materials must be developed to better withstand high temperatures, sudden temperature changes, and chemical interaction with the alkali-metal seeding materials. Durable ceramic parts are needed to replace those currently made of metal. Durable electrodes must be developed to withstand high temperatures and chemical attack, and yet they must be good conductors.

Fuel	Electrolyte	Operating Temp.	Estimated KW/ft³ (cell only)
Hydrogen and oxygen	Aqueous alkaline 50 atm.	200-240°C	2-4
Hydrogen and oxygen	Solid ion exchange membrane 1 atm.	Ambient to 50°C	3-15
Hydrogen and air	Aqueous alkaline 1-5 atm.	50-80°C	.2-1
Hydrogen and air Carbonaceous materials and air	Aqueous chemical intermediates (redox) 1 atm.	Ambient to 80°C	.2-2
Carbonaceous gases	Molten salt 1 atm.	500-850°C	1-4

COMPARISON OF FUEL CELLS under development shows types of fuel, electrolytes and power output per unit volume.

High-Temperature Fuel-Cells— A fuel cell is an electro-chemical device to convert chemical reaction directly into electricity. In contrast to conventional batteries, it consumes a low-cost fuel and an oxidant that are continuously fed into the system. It consists of an electrolyte which conducts an electric charge in the form of oxygen ions but is an insulator to electrons. The electrolyte is sandwiched between two electrodes. A voltage is created across the electrode - electrolyte sandwich when the oxygen is at different concentrations at the two electrodes.

In operation, an oxygen molecule moves through the porous cathode to the junction with the electrolyte where it picks up four electrons, forming separate oxygen ions. These migrate into electrolyte and leave a positive charge on cathode. Ions move through electrolyte to the porous anode where they release their electrons and combine again to form an oxygen molecule. The anode, receiving the released electrons becomes negatively charged; oxygen continues on into the chamber where it combines with a fuel or is exhausted from system. If two electrodes are connected to a load in an external circuit, a current will flow through the load. As long as there exists at the anode a vacuum or a fuel to react with the oxygen, there is a difference in oxygen concentration between the two electrodes, and a current will continue to flow in the circuit.

The current lab-model high-temperature fuel cell operates at 800°C. Oxygen is continuously fed into the system at the cathode, and the fuel, carbon or a carbonaceous gas is present in the anode chamber. The fuel reduces effective oxygen concentration at anode, creating a voltage across the electrode-electrolyte sandwich. Current is drawn from this system by connecting an electrical load between the two electrodes.

The development of useful fuel cells for electric power generation again hinges upon extensive materials research. Additional information is needed on the physical and chemical properties of fused salts, special ceramics and metal alloys to satisfy the critical high-temperature requirements.

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This article is based on reports by: S. J. Angello, J. Coltman, R. Ruker, and S. Way, Westinghouse Electric Corp., Pittsburgh, Pa.

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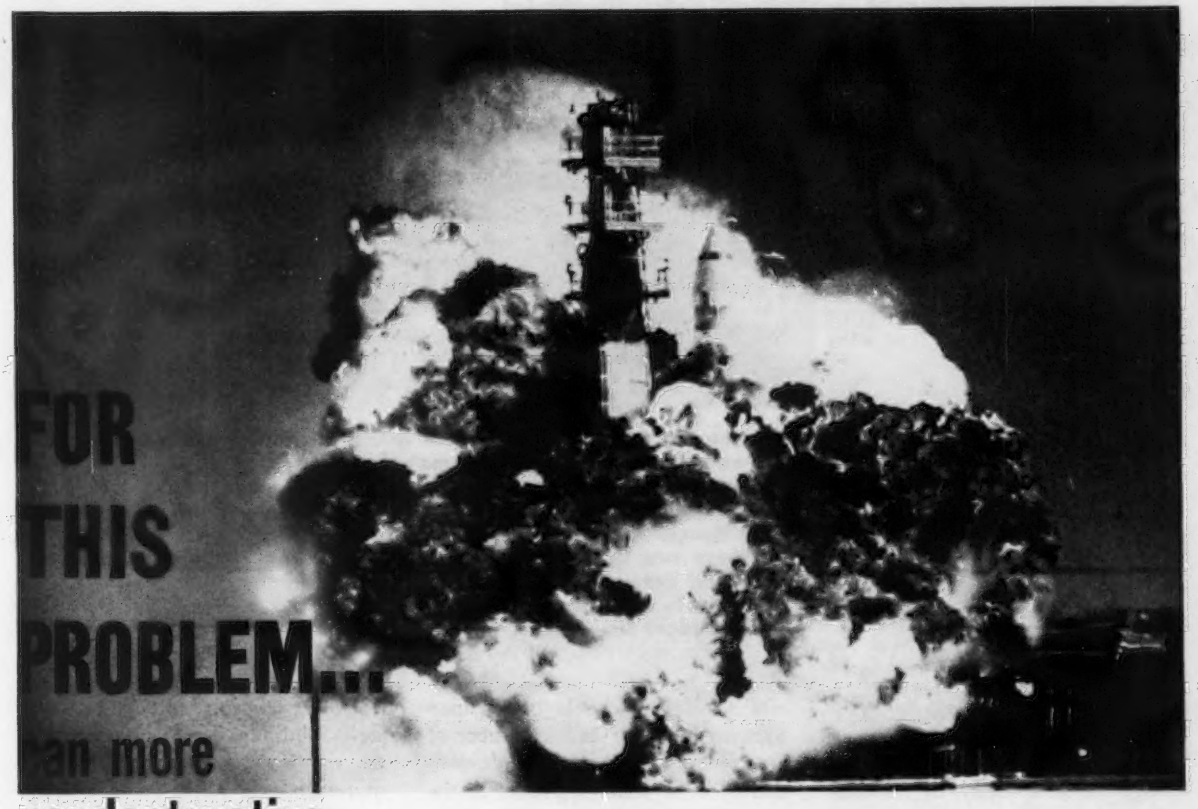

nondestructive tests help?

Often the reason why a missile fails is clear enough — after the failure. A component or system didn't function.

But this may be only half the answer.
Why did the system or component fail?

Was there an unknown defect, crack or leak or metallurgical abnormality that could have been discovered—with the proper nondestructive testing system? Or was the part or material being "worked" within a hair-line of maximum capacity of known *perfect* samples or "handbook" values—without full nondestructive testing? The nondestructive test is entirely different from a physical overload test, and proves out different things!

When the designer must assume near perfection to attain planned performance, the integrity of every element in the system, and of every material and part must be nondestructive tested—proved—and known. At present does the designer know?

Through proper use of many nondestructive tests, the means are available—or can be developed. Many of these are now provided by Magnaflux, ready for immediate use. They are used less than maximum now!

Where no existing systems meet the need, we are ready to work with any responsible agency in an authorized Research and Development program. We have 30 years of specialized testing knowledge, and a dozen or more testing systems.

We sincerely believe that lack of full use of proper nondestructive testing is a problem of national importance that must be met head-on. We offer our help.

Manufacturers of:

MAGNAFLUX-MAGNAGLO to test magnetic materials for cracks, seams, etc.
ZYGLO for nonmagnetic and other materials; cracks, leaks, etc.
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The Hallmark of Quality in nondestructive test systems

Circle 15 on Inquiry Card

Does Fiscal Foolishness Govern Defense Policies?

In an exclusive interview with Thomas G. Lanphier, Jr., dedicated patriot and outspoken critic of the administration's handling of defense matters, Philip Geddes, A&M West Coast Editor, sounded out the future of the airframe industry. Mr. Lanphier's penetrating analysis indicates the industry is not dead but is suffering from severe malnutrition, while the food locker remains full. He feels that government fiscal policies may be leading the industry and the nation to an early grave. Mr. Lanphier points to these developments as evidence:

- **Inherently cumbersome government agencies are assuming the major roles of weapons systems managers.**
- **Too much faith is being put in missiles too soon.**
- **Military's airlift and VTOL capabilities have been allowed to slide to a dangerous low.**
- **There are inadequate funds, bombers, and tankers to maintain our chief deterrent in an "instantly-ready" state.**
- **Projects are not governed by need, or lack of need, but by arbitrary budget limitations.**

The year 1959 was a big year in aviation . . . big in a bad sort of way. It was a year of change . . . change of philosophy in national defense, and corresponding change in sales philosophy of the major defense contractors. The changes were not necessarily motivated by the best considerations.

Support for manned aircraft in defense applications practically vanished in 1959. Such Air Force programs as the B-70 and the F-108 were curtailed in favor of missile systems. The Navy aircraft procurement was greatly reduced in order to accelerate the Polaris program. Reorders of existing aircraft systems were too few to provide for normal attrition.

The B-58 was a notable exception to the extinction trend. Although for budgetary reasons, its level of procurement was considerably reduced.

Budget Strategy—With the demise of the F-108 and B-70, prime contractor development of a complete weapon system seems to have passed. We expect any major systems procured in the coming years to be patterned along the lines of the "Minuteman" program. A government agency such as BMD/STL will serve in the role of Weapon Systems Manager and a number of associate contractors will develop and produce small segments of the weapon.

Financial and Technical Assistants to the Defense Secretary assumed the roles of military policy makers during 1959. Greatly reduced weight was carried by the recommendations of the Chiefs of Staff and service secretaries. Of course, the inability of the Joint Chiefs to formulate compromise decisions played a part in this shift of power. As a result, the opinions, and even the whims, of these fiscal and technical people (in DOD) may have momentous effects on the future of the nation.

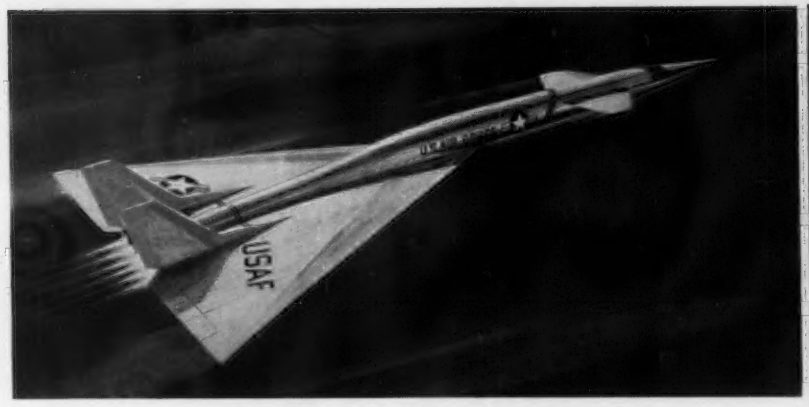
Future of Airframe — Despite the changes taking place, we are still far from seeing an end to the present airframe industry. There will always be a need for commercial aircraft, regardless of the military market. Who will build them is another thing.

Three major aircraft companies have now gone into commercial jets with their own money. They will lose a lot of it. Survival over the next five years is pretty certain, but after that the picture will change drastically.

When Convair built the 240-440 series, half the production went to the military. Current military requirements for airlift are not being met. The government could prime the fading airframe industry and bring our airlift capability out of the doldrums by buying new jets.

Someday, someone will come up with an economical VTOL . . . and then we will go into production of mass numbers like automobiles. The time spent getting people and freight to and from airports is becoming ridiculous. Helicopters, as

Thomas G. Lanphier, Jr.
"too much faith . . . too soon"



North American's Fading B-70
"day of the major prime contractor seems to have passed"

Convair's Operational Atlas?
"not last year and not now"

crude and expensive as they are, are a trend to the future. Army, and Air Force are pressing for VTOL, the industry may get some priming from their needs.

Manpower—I suspect that there will be fewer companies in the future. With more and more government intervention, there is heavy pressure to consolidate.

There will probably be fewer people in the aircraft industry than we have now. We can see this in the four divisions at Convair. Their engineering requirement curves go down sharply in the next two years at Fort Worth and San Diego. There will be a slight rise in engineering people at the Astronautics division. Budget volume is expected to stay the same with the fewer people.

Who Will Manage?—The trend is to lessen industry participation in weapons management. The government is going to manage the fewer systems of the future. If we ever have an anti-missile missile, I would bet on a government agency managing its development.

Personally, I feel that industry can manage the development of a weapons system better than government can. But political action will dictate government agencies controlling the fewer dollars available. Action of this type will cause us to lose more ground to the opposition.

The aircraft industry is accused of being inefficient and comparisons are made with the automobile industry. Our critics seem to forget that the automobile industry controls its market, at least to the extent of deciding what products will be sold.

We in aircraft are told what to build—and when to build it—by nations bent on world domination. Furthermore, decision making in our government is a cumbersome and costly process. Our military budget of 41 billion dollars is not large enough within the present system of spending. Too much money goes into archaic projects, distribution is too thin over too many projects. In some respects, better distribution would be the equivalent of more money. In addition, Inflation wipes out a part of our budget every year.

Missile Capability — There is too much faith in missiles too soon. The word "operational" to me means three things: (1) missiles in the field in numbers, (2) reliable missiles, (3) target hitting capability. The highly-touted Atlas in these terms was not operational when the President announced it last spring and is still not operational. Missiles have been over-sold as a soon-available deterrent force. It can be said in general that the overselling has not been by the people who build the missiles.

Fiscal Foolishness — I am not calling for building more and more airframes at Convair (or anywhere). My main fear is that we are missing bets on weapons systems through fiscal foolishness and cancelling out what we need for the future. There is no need to keep on building in large numbers. Let's have better appraisal of systems needed.

I also suggest that the U. S. be more realistic and wake up to the fact that we do not have funds to keep a significant element of S.A.C. in the air all the time. (This is a deterrent force that is "ready" today.)

There is one aspect of a continual alert which cannot be overlooked. Aircraft flying around with H-bombs would raise a scream of every effective propaganda that would be heard around the world.

I believe the more sensible thing to do is to keep a series of tankers airborne. We would need the tankers to refuel the bombers anyway. But, of course, coming back to realism, we don't have the tankers any more than we have the bombers, or the funds to build them.

At the moment we are faced with a decision to go out of manned aircraft. This decision is budgetary. It is not dictated by need, or lack of need, for a particular system. The word has been, "cut" where it costs most.

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A B C's of Lot Sampling

Step-by-step procedure illustrates how to interpret and use MIL-STD-105

by Irving B. Altman,
Office of Asst. Secretary of Defense
(Supply and Logistics)

The growing importance of reliability and stress on quality control are extending the use of statistical terms in the aerospace industries; statistical terminology now implements engineering reports, specifications, standards, procurement data, etc.

This article is intended to illustrate by example the meaning of terms used specifically in lot-sampling inspection. A step-by-step procedure is given in the selection of appropriate sampling plans, from Military Standard 105, when lot quality standards are referenced in a procurement or engineering document.

Lot Sampling by Attributes—Suppose a specification for an electronic component required sampling inspection by attributes to determine acceptability for visual, dimensional and electrical characteristics per MIL-STD-105. Let us assume that Section 4 (Quality Assurance Provisions) of the specification provided the following information for lot sampling inspection for these characteristics:

Inspection Level = II

Acceptable Quality Level (AQL): Major =1.0 per cent defective

Acceptable Quality Level (AQL): Minor =4.0 per cent defective

Classification of Defects: 5 Major characteristics, 9 Minor characteristics.

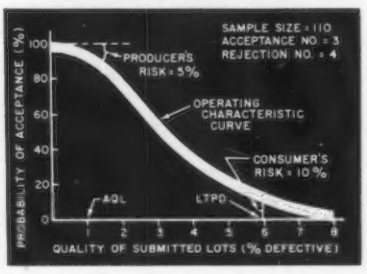
Now, it is desirable to follow the step-by-step procedure for performing the sampling inspection. Before referring to the appropriate tables of MIL-STD-105, it is necessary to assume a particular inspection lot size. Let's assume that a lot of 1000 of an electronic component is submitted for sampling inspection to determine acceptability.

Step 1—Referring to Table III on page 10, it is found that for a lot size of 1000 at Inspection Level II, the appropriate sample size code letter is K.

Step 2—With the sample size code letter determined in Step 1, now refer to Table IV to ascertain the particular sampling plans to be used. Assuming that single sampling is selected (equivalent double and multiple plans are available in MIL-STD-105), reference to Table IV A with sample data code letter K and AQL (Major) =1.0 gives the following sampling plan: Sample Size = 110; Acceptance Number = 3 defectives or less; Rejection Number = 4 defectives or more.

Similarly, the sampling plan for the AQL (Minor) = 4.0 is determined as follows: Sample Size = 110; Acceptance Number = 8 defectives or less; Rejection Number = 9 defectives or more.

OPERATING CHARACTERISTIC CURVE FOR ATTRIBUTES LOT SAMPLING PLAN



Step 3—Now that the sample size has been determined, select 110 sample units from lot of 1000 components. Since a decision concerning the acceptability of the lot is made on the basis of an inspection of the sample (collection of sample units), it is important that sample units are selected in a random and representative manner. Detailed guidance in the selection of sample units is given in DoD Handbook H105.

Step 4—Each of the 110 sample units is then subjected to all of the visual, dimensional and electrical inspections listed in the classification of defects in both the "Major" and "Minor" categories.

Step 5—If the 110 sample units contained 3 or less components with major defects and 8 or less with minor defects, the lot of 1000 meet the acceptability criteria. Assuming that the defectives in the sample exceeded the acceptance number for either majors or minors, the lot would be rejected and would require screening to remove the defective components prior to resubmission for sampling inspection.

To evaluate the risks involved in any sampling plan, it is necessary to compute the Operating Characteristics (OC) curve by using probability mathematics. MIL-STD-105 includes OC curves for various sampling plans included. The adjacent OC curve has been extracted from page 39 of MIL-STD-105 for the sampling plan having sample size = 110, acceptance number = 3, rejection number = 4 (AQL = 1.0 per cent defective) that was used above for the major category of de-

DEFINITIONS OF INSPECTION AND QUALITY CONTROL TERMINOLOGY

GENERAL TERMS

Inspection—Examination (including testing) of supplies and services (including, when appropriate, raw materials, components and intermediate assemblies) to determine conformance to contract requirements, which include all applicable drawings, specifications and purchase descriptions.

Examination — An element of inspection consisting of investigation, without use of special laboratory appliances or procedures, of supplies and services to determine conformance to those specified requirements which can be determined by such examination. Examination is generally non-destructive and includes (but is not limited to) visual, auditory, olfactory, tactile, gustatory and other examination; simply physical manipulation; gaging; and measurement.

Testing—An element of inspection and generally denotes determination by technical means of physical and chemical properties or elements of materials, supplies or components thereof, involving not so much the element of personal judgment as the application of established scientific principles and procedures.

Reliability—The probability that the product will give satisfactory performance for a given period of time when used in the manner and for the purpose intended.

INSPECTION CLASSES USED IN GOVERNMENT PROCUREMENT

Qualification Inspection—Such examination and testing of a product as may be necessary to determine whether or not the product conforms to all qualification requirements of the applicable specification. Qualification inspection is normally conducted independent of a procurement action and at the request of a supplier seeking inclusion of his product in a Qualified Products List. (In a more limited sense, the term qualification testing may be used in lieu of the term qualification inspection where conformance with qualification requirements is determined solely by tests.)

Acceptance Inspection — Examination and testing to determine conformance of the supplies or services to certain specified requirements which serve as a basis for acceptance.

Comparison Inspection — Examination and testing performed at intervals, on samples representative of production runs, after the supplies or services have passed the qualification inspection.

LOT SAMPLING INSPECTION TERMS

Acceptable Quality Level (AQL)—Maximum number of defects per 100 units which can be considered satisfactory as a process average.

Acceptance Number—A number associated with each sample of an attributes sampling plan. An inspection lot is passed for an inspection if, after inspection of a particular sample, the total number of defectives (or defects, if the AQL is expressed in defects per hundred units) for that inspection found in that and all preceding samples from that inspection lot, is equal to or less than the acceptance number associated with that sample.

Critical Defects—Defects that judgment and experience indicate could result in hazardous or unsafe conditions for individuals using or maintaining the product; or, for major end-items, units of product, such as ships, aircraft or tanks, a defect that could prevent performance of their tactical function.

Consumer's Risk—The risk in a sampling plan that a lot of unacceptable quality (Lot Tolerance Percent Defective) will be accepted by the sampling plan. This risk has been standardized in many sets of sampling tables at 10 per cent.

Defect—Any deviation of a unit of product from specified requirements. A unit of product may contain more than one defect.

Defective Unit—A unit of product which contains one or more defects.

Double Sampling—Sampling inpection in which the inspection of the first sample leads to a decision to accept, to reject or to take a second sample; and the inspection of a second sample, when required, then leads to a decision to accept or to reject.

Inspection by Attributes — Inspection wherein certain characteristics of the sample units are inspected and classified simply as conforming, or not conforming, to specified requirements. If desired, the degree of nonconformance may be further categorized, using such classifications as critical, major and minor.

Inspection Level—A term used to indicate the relative number of sample units for a given amount of product. All other things being equal, a higher inspection level entails a lower risk of acceptance by the Government of a lot of inferior quality, and vice versa.

Inspection Lot — A specific quantity of similar material, or a collection of similar units, offered for inspection and acceptance at one time.

Lot Sampling Inspection—The procedures by which decisions are made to determine acceptability of a lot of product based on results of examination and testing of a sample or samples selected from the lot.

Lot Sampling Inspection Plan—A specific plan which provides sample size(s) and criteria for determining acceptability of the lot based on sample results.

Lot Tolerance Per Cent Defective—That quality of submitted lot that has a small chance of being accepted by a particular sampling plan. This small-chance probability is usually established as 1 in 10 or 10 per cent.

Major Defects—A defect, other than critical, that could result in failure, or materially reduce the usability of the unit of product for its intended purpose.

Minor Defects—A defect that does not materially reduce the usability of the unit of product for its intended purpose, or is a departure from established standards having no significant bearing on effective use or operation of unit.

Normal Inspection—That inspection which is used when there is no significant evidence that the quality of product being submitted is better than or poorer than specified requirements. Also, normal inspection is usually used at the start of a contract, when no quality history of the product exists.

Operating Characteristic Curve—A curve showing the relation between the probability of acceptance and quality of submitted lots.

Producer's Risk—The risk in a sampling plan that a lot of product of acceptable quality will be rejected by the sampling plan as a result of a pessimistic-looking sample being drawn. This risk has been standardized in many sets of sampling tables at 5 per cent.

Rejection Number—A number associated with each sample of an attributes sampling plan. An inspection lot is rejected for an inspection if, after inspection of a particular sample, the total number of defectives (or defects, if the AQL is expressed in defects per hundred units) for that inspection found in that and all preceding samples from that inspection lot, is equal to or greater than the rejection number associated with that sample.

Tightened Inspection—Inspection which is used when there is significant evidence that the quality of product being submitted is poorer than specified requirements. A lot of inferior quality is more likely to be rejected when subjected to tightened inspection than it is when subjected to normal inspection.

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fects. This OC curve shows the probabilities of accepting lots containing 0 to 7 per cent defective. For example, if lots of components with 1 per cent defectives were submitted, approximately 95 per cent of such lots (19 out of 20) would be accepted by the sampling plan. About 1 lot out of 20 meeting the AQL = 1 per cent defective would, on the average, yield a sample with 4 or more defectives and be rejected, even though the lot is of acceptable quality. Thus, this 5 per cent is referred to in the SQC literature as the "Producer's Risk" for a particular sampling plan. Examining the OC curve, it is possible to ascertain the probabilities of acceptance for lots of various qualities. As lot quality deteriorates, the chance for meeting the acceptance criteria of the sampling plan decreases. Thus, for lot quality of 6 per cent defective, the probability of acceptance of the sampling plan is approximately 1 in 10, or 10 per cent. The 6 per cent defective lot quality (or undesirable lot quality) is referred to in SQC as the "Lot Tolerance Per Cent Defective," and the chance that this lot quality will be accepted by the sampling plan is specified as the "Consumer's Risk." The consumer's risk in many sets of sampling plans is established as 10 per cent.

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REFERENCES

Military Standard 105A, "Sampling Procedures and Tables for Inspection by Attributes," September 1950.

DoD Supply & Logistics Handbook H105, "Administration of Sampling Procedures for Acceptance Inspection," April 1954.

Military Standard 109, "Inspection Terms and Definitions," June 1955.

ASTM Manual on Quality Control of Materials, 1951.

ASQC Standard A1, 1951.

ASQC Standard A2, 1957.

WHAT TO EXPECT FROM ULTRASONICS IN

Testing Solid-Propellant Rocket Motors

Finished units can be checked for bonds at case-to-liner, and liner-to-propellant interfaces; Checking "grain" soundness is next step

by R. E. Klient and R. D. McCown
Ultrasonic Testing & Research Lab.
Div. of Automation Ind., Inc.

A simple, solid propellant motor consists of three basic elements. (1) The container, shaped like a large tin can. (2) The rubber-like liner coating on the container. Thickness ranges from a few thousandths to as much as ¼ in. (3) The propellant material, which is cast into the lined container with a core mold designed to give best burning area.

Special bonding agents are often used to join the three elements. Testing for completeness of the bond at either of the two interfaces, and for voids or cracks in the propellant itself, are two of the problem areas in which the motor manufacturers have turned to nondestructive methods for help.

Contract and Findings—Wright Air Development Center (WADC), in June, 1959, granted an R&D contract to Ultrasonic Testing and Research Laboratory for development of ultrasonic techniques. With the cooperation of the principal suppliers of solid propellant motors, some interesting findings have been made. Summarized, they are:

- The detection of unbond between the rocket-motor case and the liner presents no particular problem. With a few detailed specifications and adequate scanning equipment, this type of inspection can be performed with no difficulty.
- The detection of liner-to-propellant defects is somewhat less routine with the present state of the art. Refined instrumentation will be needed along with considerably more development work before absolutely valid measurements can be made.
- Detection of voids within the propellant hinges primarily upon the development of higher energy sources which will produce this energy at present detection frequencies (1.0 to 5 megacycles). Development is proceeding at a fair rate and some results can be expected within the next year.

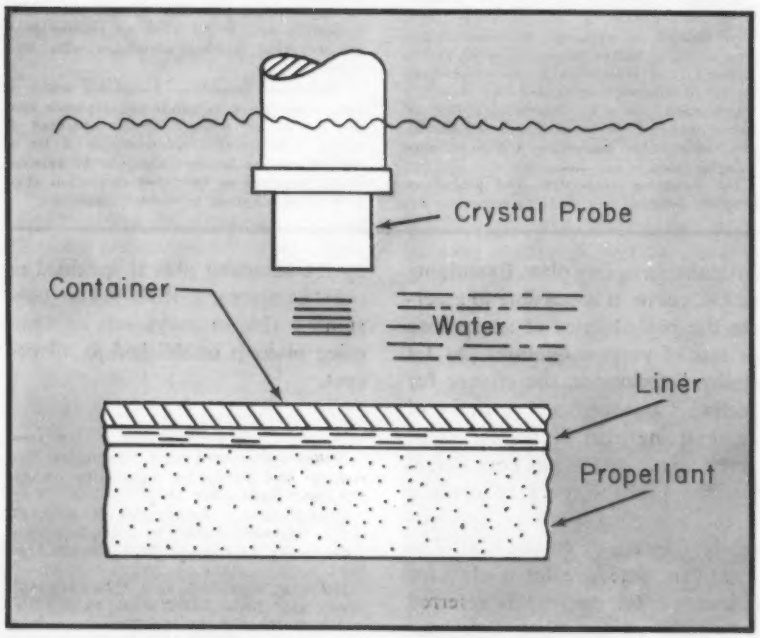

FIG. 1. TEST LAYOUT of typical case-liner-propellant combination shows ultrasonic probe and liquid test medium.

Test Method—A major obstacle in testing is to propagate ultrasonic energy through the consecutive interfaces, and still maintain sufficient amplitude to detect voids. At high power, the amplitude loss is accompanied by a multitude of signals reflected from the case-to-liner interface, which tend to confuse any other information.

Fig. 1 shows a typical cross-section of a case-liner-propellant combination. Using conventional pulse-echo type ultrasonic equipment, a

short burst of high frequency energy can be generated at the crystal and transmitted through an oil or water coupling into the container material. A considerable portion of the energy reflects from the couplant-to-metal interface, but sufficient energy enters the metal to set up a series of vibrations which bounce back and forth between the two surfaces of the metal. Each time the energy reaches the original entry surface, a small quantity of sound escapes and heads back towards the crystal. When the crystal receives the energy reflected from the front surface, the pulse is electronically displayed on a cathode ray tube as a "blip." Likewise a "blip" is displayed for each succeeding round trip that the sound makes between the two metal surfaces. The resulting scope pattern is shown in Fig. 2, where the horizontal distance between the "blips" is proportional to the thickness of the metal case. The height of "blip" diminishes with each round trip due to attenuation impedance, and other losses.

Liner-to-Case — In the same manner that sound escapes from the top surface of the case with each round trip, a small fraction of the energy is released from the bottom surface and will penetrate the rubber liner material. The amount of energy which reaches the liner is dependent upon the quality of bond between the case and the liner. Since energy qualities must be conserved, the energy which penetrates the liner subtracts from the energy reflected from the case-to-liner interface. Thus, a good bond will reduce the magnitude of round trip signals from the metal case. The reduced signal pattern due to good bond is shown in Fig. 3.

The ratio of transmitted to reflected energy at the metal-to-liner interface is a function of the accoustical impedances of the materials. If the metal and liner surfaces are separated, then the interface is one of metal-to-air or some other gas. The impedance mismatch between metal and gas is much greater than between metal and rubber, and there is a higher reflectance.

Liner-to-Propellant — Assuming that a certain portion of the energy penetrates the liner and makes it through to the liner-to-propellant interface, a similar phenomenon takes place. If the liner-to-propellant interface is well bonded, then the energy is almost entirely carried over into the propellant. (This occurs due to the similarity of impedances of the liner and propellant, both being rubber base materials.) If the surfaces are unbonded, then there is a drastic impedance mismatch and most of the sound is reflected. At this stage, however, the quantities of energy are so small that it is difficult to distinguish between a small reflection and no reflection. The problem is made exceedingly more difficult due to the presence of several round trip echoes from the case material still appearing on the presentation unit. In Fig. 4, reflection patterns show the liner-to-propellant interface as being slightly separated from the reflection pattern from the case material.

Propellant Test — If enough energy can be generated at the proper frequency, it is possible to end up with sufficient energy in the propellant to withstand the high attenuation and reflect from voids. Then if a means is conceived to separate the flaw signals due to propellant defects from the multiple echos from the container, the detection of faults within the solid fuel is possible. Progress along these lines is somewhat dependent upon developments in the electronic and crystal fields.

Because changes in the cathode ray presentation are fairly small when delineating areas of bond and no bond, it is difficult for the human eye and mind to keep up with the changes when the crystal is scanned over different portions of the motor. In fact, this becomes impossible if scanning rates are increased to the limit of present scanning equipment. Some means, then, is necessary by which all the data can be integrated and presented in the form of a permanent record.

Recording Techniques — Various means have been proposed for presenting ultrasonic test data. At present there are but three visual methods which have received wide acceptance in the industry. These three methods have been defined as A-Scan, B-Scan, and C-Scan. (See Fig. 5)

The method most adaptable to rocket motor inspection is the C-Scan. This method provides a plan view of the part under test, and voids are shown in their full plan areas. The technique is usually accomplished by electronically time gating the A-Scan trace. The time gate may be adjusted to select from

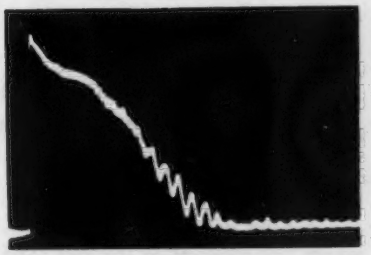

FIG. 2. CATHODE-RAY "BLIP" pattern for rocket-motor container. Horizontal distance between blips represents case thickness.

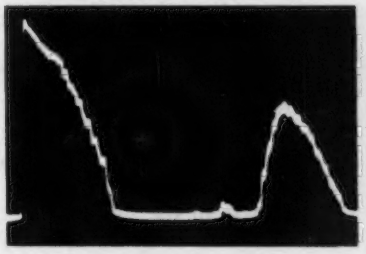

FIG. 3. CASE-TO-LINER bond is shown in A-Scan pattern. Good bond reduces the magnitude of "round-trip" ultrasonic energy.

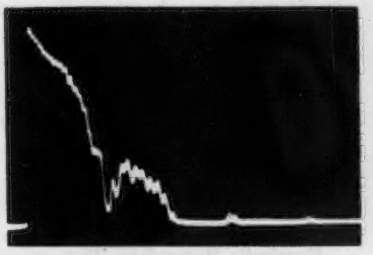

FIG. 4. VOID IN BOND between liner and propellant shows up as sudden increase in reflected energy. (Photo taken in ideal conditions.)

Three basic methods of data readout used, C-Scan best suited to solid propellants

the A-Scan data only those signals which are relevant to the test. The gate sensitivity may also be adjusted so that only signals of a certain predetermined magnitude will be recorded.

The C-Scan system used by Ultrasonic Testing and Research Laboratory on rocket motor work is a bit more complex than some of the earlier systems employed for general service applications. The uniqueness of the system lies in its special gate sensitivity arrangement. The signal from the sonic test set is fed into the recorder circuitry in its entirety. The A-Scan information is then sorted out by means of a very precise time gating circuit which is adjusted by the operator. The amplitude of the signal in the gate is read out electronically and fed to the recorder in the form of a DC current. The DC voltage across the recorded is proportional to the original signal amplitude, so that the recorder receives information in gradations of amplitude, rather than a mere "on" or "off" signal.

Facsimile Recorder—The actual recording device utilized in the system is a facsimile paper recorder similar to the type used in the wire photo service. The paper is predampened with a conductive chemical which reacts electrochemically with one of the electrodes to produce gradations of color in proportion to the applied current. Therefore the paper is capable of transposing amplitude variations, via current variations, into gradations of color tone.

The current is supplied to the paper by means of an electrode on either side of the paper. One electrode is a thin bar equal in length to the width of the paper and supplies the metallic ions which produce the color change, similar to a plating operation. The other electrode is a wire wound around a drum in the form of a helix. The rotation of the helix is mechanically coupled to the traversing motion of the crystal probe. The indexing of the probe carriage is coupled to the mechanism which feeds the paper through the electrodes. Thus the paper receives X and Y coordinate information directly from the crystal probe, while getting amplitude data from the sonic set. The resulting recording is a plan view picture revealing the sub-surface conditions of the part under test, and all this in several shades of half-tone. The ratio of part size to recording size can be varied depending on the mechanical linkages, but one-to-one is the more preferred ratio if the part is not too large.

Some Results—To show some typical results, a test can be followed through from beginning to end.

Fig. 6 shows one of many test specimens fabricated. The sample consists of a section of container material to which has been bonded a polysulfide rubber liner with intentional voids placed at the case-to-liner interface. On the far side of the liner material another artificial void has been simulated. (The fact that the sample contains no propellant material is incidental to the test, since essentially no energy would pass the air interface anyway.) The sample was immersed in a scanning tank and elevated a short distance from an aluminum back reflector plate.

The crystal probe was aligned normal to the sample and the following A-Scan patterns observed.

- **Crystal Position 1:** With the crystal over the case-to-liner void, the A-Scan photo in Fig. 2 shows the pattern of several back echos from the container material.

- **Crystal Position 2:** With the crystal over the area of good bond, the over-all magnitude of the back echo pattern is significantly reduced, as shown in Fig. 3. Note also that another pattern of signals appears toward the right hand side of the trace. These additional signals were determined to be a result of energy reflected from the aluminum reflector plate. The indiction is that some sound had penetrated the entire sample, reflected from the plate, penetrated the sample again, and arrived back at the crystal with enough amplitude to "ring" the crystal. Based upon impedance cal-

"A" SCAN "B" SCAN "C" SCAN

FIG. 5. THREE BASIC SYSTEMS for displaying ultrasonic test data are "A," "B," and "C" Scan. A-Scan is read directly from cathode-ray tube. B-Scan transposes A-Scan to side elevation. C-Scan gives overall planview.

culations, and neglecting attenuation and other losses, the amount of energy returning to the crystal under these conditions was only about 0.03 per cent of the original transmitted energy.

• **Crystal Position 3:** With the crystal over the simulated liner-to-propellant void, the A-Scan photo in Fig. 4 shows a still somewhat dampened pattern from the container. But, a distinct pattern representing the liner-to-propellant void is now also visible. Note that the reflector signal has now disappeared due to complete reflection of the energy at the air interface.

The three A-Scan photos represent three distinct conditions of the case-to-liner and liner-to-propellant bonds. In Fig. 3, if the time gate is adjusted so as to include only that portion of trace just to the right of the dampened pattern from the container, then the gate will be "empty" and no information will reach the recorder. However, if the crystal passes over an area exhibiting an A-Scan trace as in Fig. 2 or Fig. 4, the gate will be triggered and will start feeding data to the recorder in the aforementioned manner.

By means of an electronic modification, the data from the gate can be completely turned around so that "lack of signal" will record and vice versa. In this "negative picture" the defective areas are without color and the good areas are dark. This negative system of recording is used for small parts so that the outline of the part shows clearly.

Problems and Solutions — Although the "negative" recording was obtained under somewhat ideal conditions, it proves that the detection of unbonds at the two interfaces is plausible. Under these particular conditions it was possible to record both types of voids with the same gate setting. It seems probable at the present time that the coincidence of flaw signals, time wise, on the A-Scan presentation will in most cases permit simultaneous gating and recording of both case-to-liner and liner-to-propellant

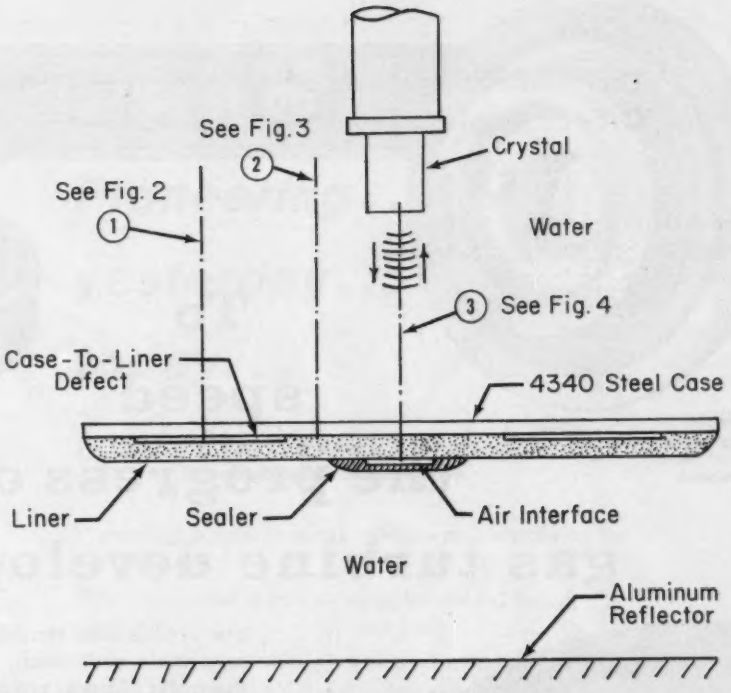

FIG. 6. TEST SAMPLE shows cross section of good bond and void. Data record from probe positions 1, 2 or 3 can be seen in Figs. 2-4.

defects. One type of defect may easily be distinguished from the other by observation of the A-Scan trace, as illustrated in Fig. 2 and 4.

An area of concern has to do with the pressure effect at the unbonded interfaces. It was speculated that if two surfaces are unbonded, yet at the same time are in very intimate contact with one another due to pressure caused by the weight of the propellant, the interface would appear in the test to be bonded. Current investigation shows, however, that the pressure needed to bring about this condition far exceeds the pressure possible to attain at the interface.

Another area of difficulty is that of fabricating good representative samples of defective material. The usual method involves using a silicon grease to prevent bonding at the interfaces. This system leaves much to be desired, since the accostical impedance of the grease is often similar to the impedance of the rubber materials. Under these conditions, the energy has a tendency to carry through the unbond and cause very little reflection. Since true motor voids would contain not much grease, the test sample approach adds unnecessary problems not present in the actual inspection of motor combinations. Present efforts are directed towards obtaining better samples.

Various other ultrasonic approaches to the overall problem are being considered. Among these are twin crystal techniques (send and receive), special electronic systems for reducing spurious reflections, and very high energy low frequency crystals for penetrating the propellant material. Special scanning equipment for rotational scanning of the motor cases is under preliminary design.

✦

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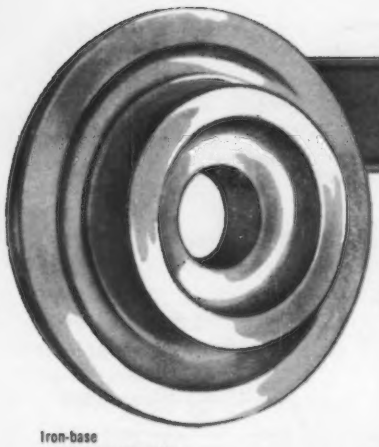
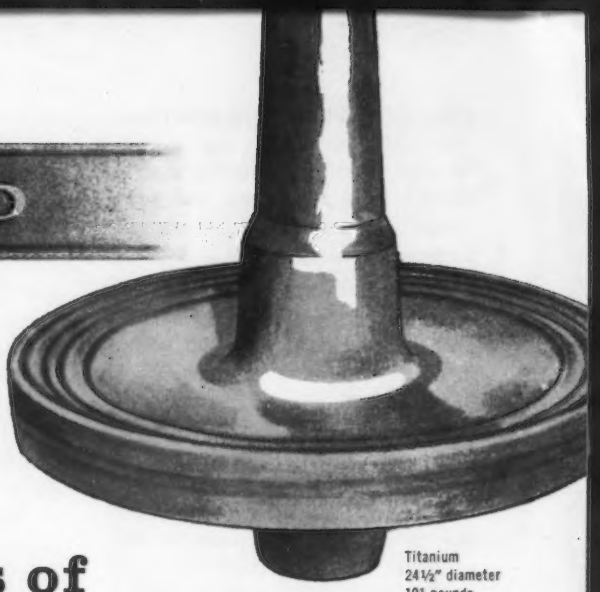


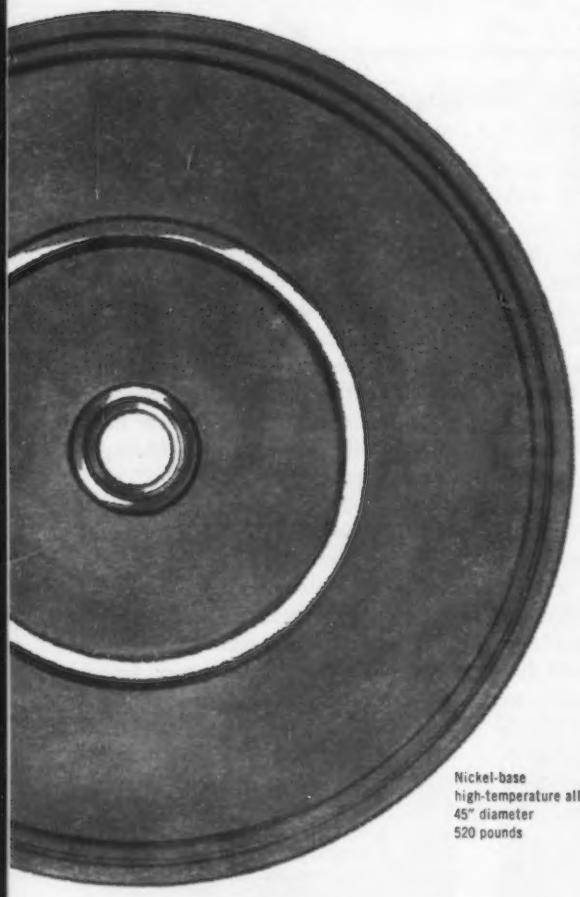
Iron-base
high-temperature alloy
21½" diameter
244 pounds

FORGED



Titanium
24½" diameter
191 pounds

To speed the progress of gas turbine development



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Flow: 10 scfm.
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60 inch-lb. at 10,000 psig.
Panel mounting
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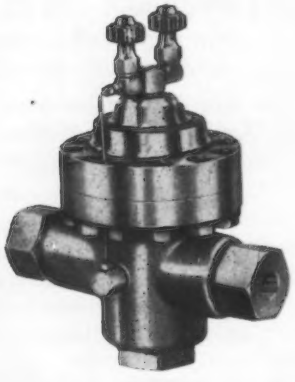

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Secrets of Successful Seal Design

Fundamentals — No. 1 of A Series

SPACE — Around Sealol the bane of our existence is the job which comes to us designed in toto — "no changes allowed. Please fit your mechanical seal into this space". If there isn't space enough, the solution will usually be a compromise with performance standards sacrificed. As an example, a 1" diameter shaft will require a standard Sealol seal with a .531" operating range and a mating ring preferably .250" for a total of .781". This particular seal allows .020" for tolerance stack-up and shaft end motion. But suppose you have allowed us only .700" with a stack-up tolerance of .040"? We may be able to reduce the space required for the seal without sacrificing performance but only if the stack-up tolerance can be reduced to .020". In some cases selective assembly or shimming can produce satisfactory operating life with a bare minimum of axial space. ***Moral*** — *Send us your design before it is frozen.*

P.S. Diametrical space requirements do not bother us, but we do urge you to take into account the relative co-efficient of expansion of the stainless steel cup of our seal and the material into which you want it assembled. Sealol's Bulletin #7, Page 6, has some charts which may be helpful.

CHARACTERISTICS — In the old days, say ten years ago, you could spot an industrial seal application as distinguished from an aircraft high-performance type of application, a mile away. The former provided for rotation of the axial movable part — the latter invariably provided for these axial movable parts to be stationary in respect to the shaft. Times have changed, but designers generally favor the stationary seal where overall axial space is at a premium since it requires only 40 to 70 percent of the space of a rotary seal. Naturally, they are also much lighter. Furthermore, when shafts start turning at speeds beyond 5000 RPM, springs, pins and assorted hardware have a way of losing their functional abilities and for these situations, the stationary seal is mandatory. On the other hand, rotating seals are usually more rugged in their construction, and they are self-cleaning. They are used extensively on industrial pumps, blowers and compressors. We don't propose to be too dogmatic about the small table shown below, but it serves to delineate our present parameters for stationary and rotating seals.

MAXIMUM OPERATING CONDITIONS

	Stationary Seal	Rotating Seal
Shaft Speed	100,000 RPM — 1/4" Dia.	5,000 RPM to 3" Dia.
Temp.	—425° to + 1000°F	—60° to +450°F
Pressure	2,000 psi	1,200 psi

Note: Maximum conditions indicated do not mean that all are available in a single seal.

Viton-A and Teflon are registered trademarks of E. I. du Pont de Nemours & Co., Inc.

PRESSURE — One of the most critical conditions, but one of the most inconsistent, is pressure. Many the time there has been much Sealol head-scratching over a 2 lb. pressure differential in one test rig, whereas pressures in excess of 2000 lbs. were being handled in routine fashion in an adjoining rig. We would be delighted to exchange data with you on pressure phenomena, but in the meantime, you may be interested in the following tidbits. Since operating life of a seal is a function of face load, pressure considerations can be really critical. We design to a unit face-load usually of 8 to 40 psi. depending, of course, on the spring and area involved. Hydraulic pressure of the fluid being sealed and the fluid film pressure across the seal face must also be reckoned with. Around our premises, our engineers banter back and forth a semantic generality called 'seal balance'. If you are interested, ask us for NCIH Paper "Factors in Designing for Mechanical Seal Applications to Hydraulic Equipment". Seal size has a considerable bearing on pressure capability, and as shaft diameters go up into sizes, say above 12 inches and pressures go to 500 psi, seal ring sections become quite massive to prevent distortion. Incidentally, 100 psi is about the maximum pressure we recommend for an unbalanced seal. For higher pressures, we must reckon with interface film destruction resulting from non-balanced face loads.

SHAFT SPEED — Top-flight designers are certainly stretching seal performance in many ways. Not the least is your incredible ability to cram into minute space great horsepower performance. This is meaningful to us, because the shaft speeds you now call for are exceeding, in many instances, speeds of 50,000 RPM. Of course, a 100,000 RPM — ½" shaft is probably within the capability of existing seals, but from a seal standpoint, the relative surface speed of the seal faces should not exceed about 18,000 FPM under ideal conditions. Irrespective of face materials, this seems about maximum for full contact and leakproof sealing today.

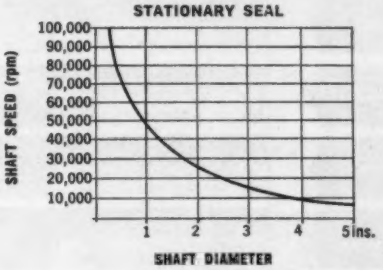
TEMPERATURE — As seal designers, our temperature goes up when you ask us for high performance beyond 450°F. ambient. This is about the usable limit for today's elastomers, such as Viton-A and Teflon. However, this too may be misleading. There are Sealol-Flexibox elastomeric packed seals doing a beautiful job in oil refineries with pump temperatures of 750°F. The secret here is, of course, controlled temperature at the seal to produce seal ambients below 450°F. However, within the last two years, Sealol's welded bellows seals are performing well at temperatures to 1000°F. Our thought for the day — if it can't be cooled to within elastomeric limits — consider the all metal welded bellows seal.

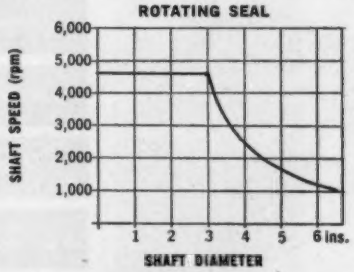
MOUNTING ARRANGEMENT — If possible, the fluid being sealed should be on the O.D. of the sealing faces. Centrifugal force of any fluid between the faces will then work in your favor to prevent seepage between the rubbing faces. Seals can function satisfactorily with fluid on the inside of the seal faces. We can both avoid long hours on the assembly line later looking for leaks if we arrange matters so that the fluid is on the outside of the face.

RUN OUT — We've heard many definitions of run out, but here is ours: The deviation of the plane of the rotating ring from a plane perpendicular to the axis of the shaft. It usually results from a lack of squareness of the rotating sealing surface to the axis of rotation. It causes a wobble of the ring and tends to bounce the seal ring away from contact at high rubbing speeds. For a 2" shaft at 20,000 RPM, run out should not exceed .0005" at the point of contact.

If these thoughts have aroused your interest, write to us with your questions, and we will be glad to elaborate.

The following tables define maximum shaft speeds under optimum conditions.





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THEORETICAL PERFORMANCE OF ROCKET PROPELLANT COMBINATIONS

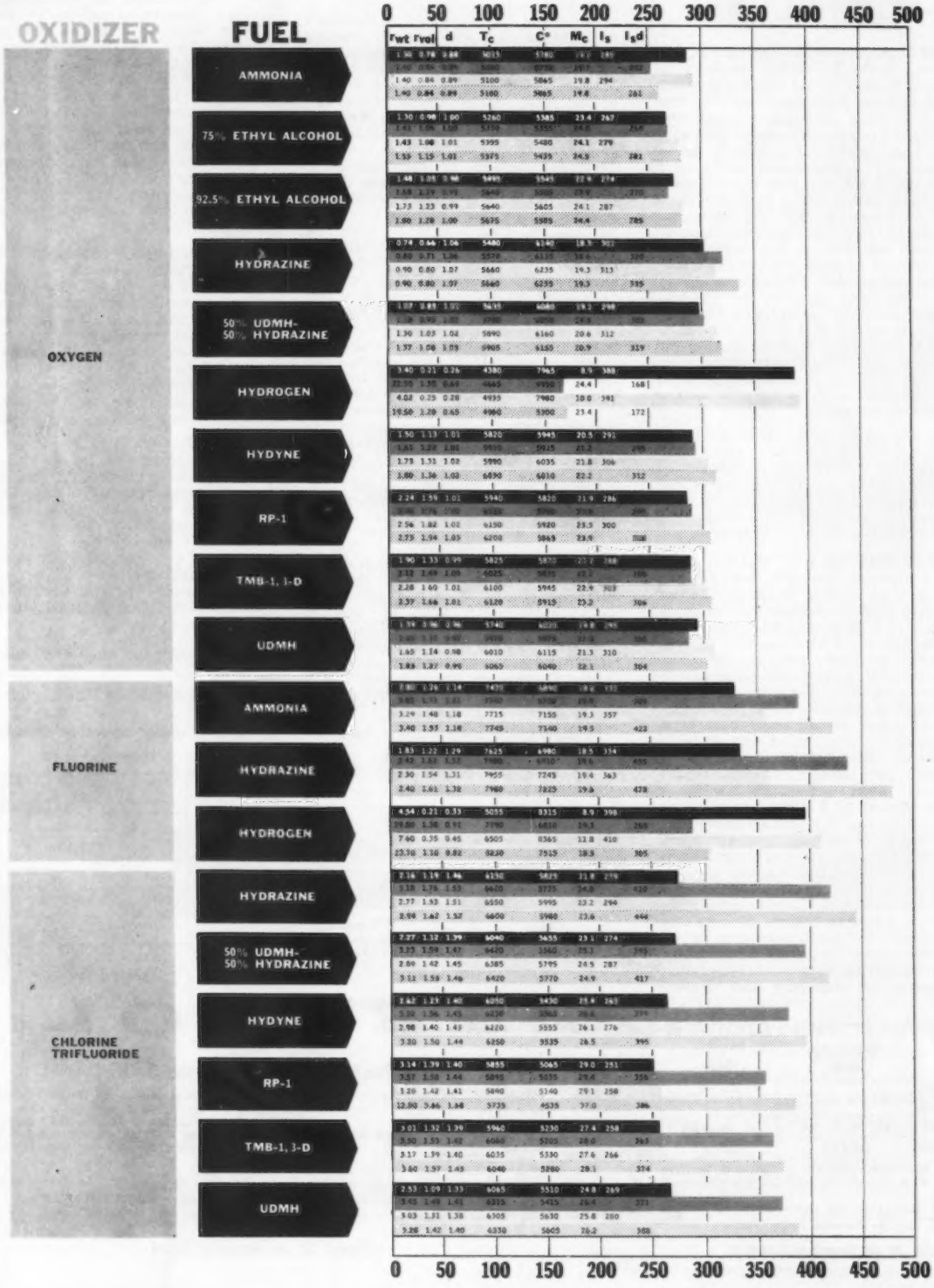
Courtesy of the Rocketdyne Theoretical Chemistry Unit

CONDITIONS

Combustion chamber pressure = 1000 psia.
Nozzle exit pressure = 14.7 psia.
Optimum nozzle expansion ratio $\left(\frac{\text{exit area}}{\text{throat area}}\right)$
Contraction ratio $\left(\frac{\text{chamber area}}{\text{throat area}}\right)$, assumed to be infinite
Adiabatic combustion
Isentropic expansion of ideal gas
Compositions expressed in weight percent

TO APPROXIMATE I_s AND I_sd AT OTHER CHAMBER PRESSURES

Pressure	Multiply by
1000	1.00
900	0.99
800	0.98
700	0.97
600	0.95
500	0.93
400	0.91
300	0.88



SYMBOLS (Theoretical)

- Max specific impulse, I_s, lb-sec/lb frozen equilibrium*.
- Max density impulse, $I_s d$, (sec)(g/cc) frozen equilibrium*.
- Max specific impulse, I_s, lb-sec/lb shifting equilibrium**.
- Max density impulse, $I_s d$, (sec) (g/cc), shifting equilibrium**.

r_{wt} = Weight mixture ratio, wt. oxidizer/wt. fuel.

r_{vol} = Volume mixture ratio, vol. oxidizer/vol. fuel.

d = Bulk density, $\dfrac{r_{wt}+1}{\dfrac{r_{wt}}{d_{oxidizer}}+\dfrac{1}{d_{fuel}}}$, g/cc***.

T_c = chamber temperature, F.

C^* = Characteristic velocity, ft./sec.

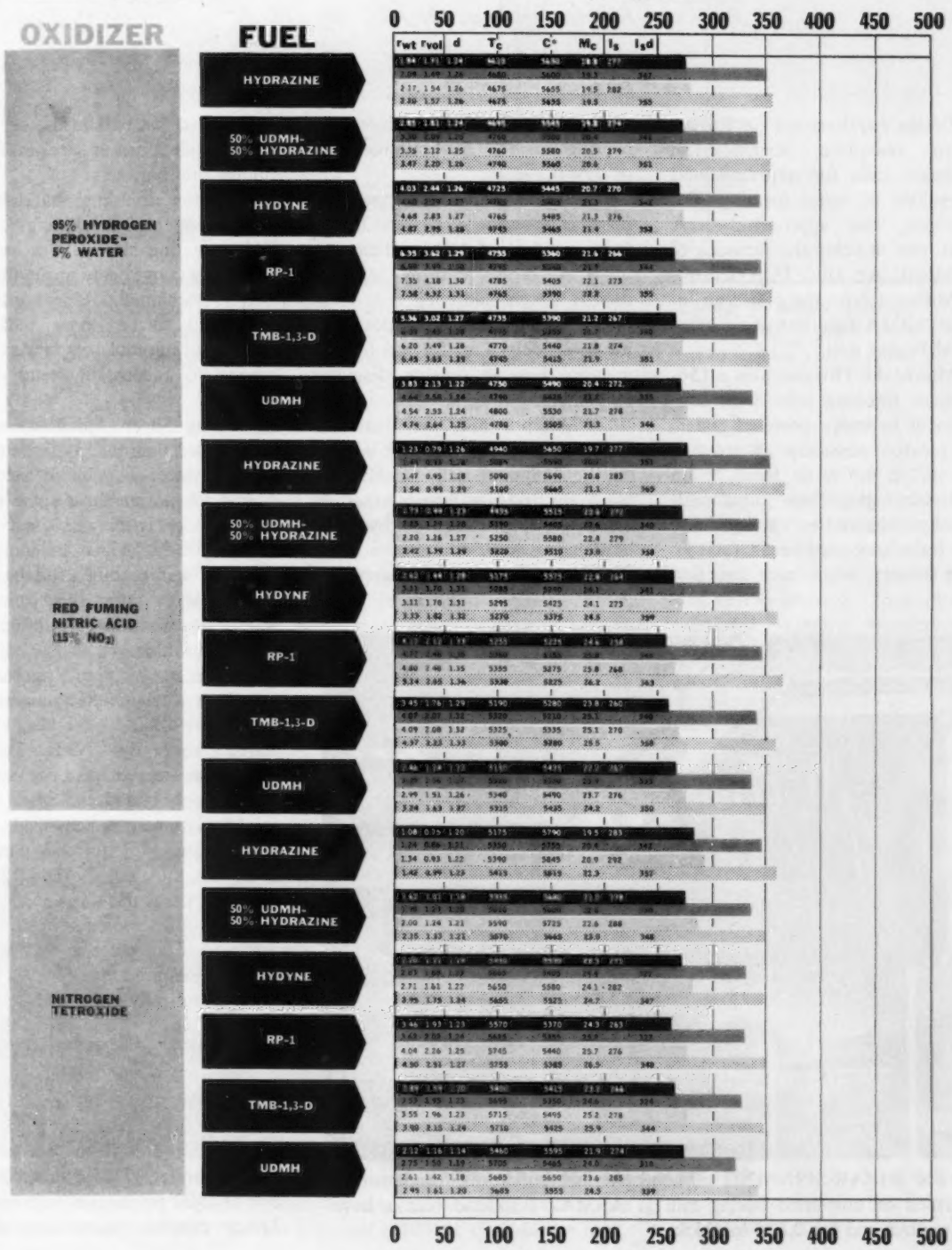
M_c = Average molecular weight of combustion products at T_c.

$C_f = I_s \dfrac{g}{C^*}$

* = Frozen equilibrium: Condition of fixed chemical composition of gaseous products throughout expansion in nozzle.

** = Shifting equilibrium: Condition of changing chemical composition of gaseous products throughout expansion in nozzle.

*** = The density at the boiling point was used for those oxidizers or fuels which boil below 68° F at one atmosphere pressure.



TMB-1,3-D IS N,N,N',N'-TETRAMETHYL-1,3-BUTANEDIAMINE

HYDYNE IS A 60% (BY WEIGHT) MIXTURE OF UDMH AND 40% DIETHYLENETRIAMINE

RP-1 IS A HYDROCARBON FUEL IN ACCORDANCE WITH SPECIFICATION MIL-F 25576B(USAF)

Capping Saturn's Tanks

Spinforming used to shape aluminum hemispheres on huge fuel and oxidizer tanks

By W. A. Wilson,
Acting Chief;
Fabrication Assembly Eng. Lab., ABMA

Design requirements for Project Saturn one-piece hemispherical bulkheads calls for unprecedented dimensions in metal forming. For assurance, two approaches were taken: one utilizing the facilities of the Missile Air Div., U. S. Chemical Milling Corp.; the other, an in-house ABMA facility using a converted boring mill.

Missile Air Division uses a 156-in. diam spinning lathe with conventional hydraulic-powered rollers manipulated manually. Blanks of 139 in.^{2} x 0.375 in. thick, 5086 aluminum alloy are purchased, and circle sheared to 130-in. diam. The technique used is as follows:

- Blank is mounted on first preform, and using heat, edges spun over to form a flat-bottomed pan of 114-in. diam.
- Again using heat, the preform is spun onto a second preform mandrel of 108-in. diam.
- A third preform mandrel used is a truncated cone with a 42-in. diam center-flat with sides sloping at 25 deg. Part formed on this mandrel has an outside diameter of 108 in.
- After heating the aluminum to maximum temperature, it is spun on the final mandrel. Heat is applied for only a few minutes to maintain strength imparted by strain hardening. After spinning, a minimum hardness value of Barcol 75 is required for bulkheads, or additional roller passes are made to obtain this hardness.
- After spinning, bulkhead is positioned on machining lathe; while rotating slowly in a vertical plane, the convex side of the formed part is machined. A hydraulically controlled tracer inside bulkhead keeps cutting-tool operating with respect to a constant metal thickness.

Power Shear - Spinning — This was undertaken as a second approach since: (1) blank size required for power shear-spinning of hemispheres is only 10 per cent above the final diam of the part, and this was readily available; (2) equipment to power shear-spin this size part was not available but highly desirable.

Power Shear-Spinning process is based on a trigometric relationship referred to as the "sine-law," illustrated adjacently. Metal is displaced in increments parallel to centerline of rotation. Since axial thickness remains unchanged, final wall-thickness of formed part, at any point, must equal original blank thickness times the sine of the angle formed by intersection of rotation axis and a tangent line to the surface at that point.

Hydraulically - powered roll is motivated by a 10-in. diam cylinder operating at 1000 psi maximum pressure. This is mounted on a 45 deg angle to the bed of the mill. A 6-in. diam hydraulic cylinder controls the cross-feed rate of the powered roller. This cylinder operates at 1500 psi maximum pressure. Tracer controls, manufactured by

POWER SHEAR-SPINNING of hemispherical bulkheads for Saturn is performed on converted boring mill at ABMA. Bulkhead blanks have 114 in. diam and are 0.625 in. thick.

T_1 = Original blank thickness
T_2 = Part thickness at any point (P)
ΔM = Increment of metal
α = Angle formed by intersection of tangent line to point (P) and
R = % Reduction at any point (P)

$$\text{Sine } \alpha = \frac{T_2}{T_1}$$

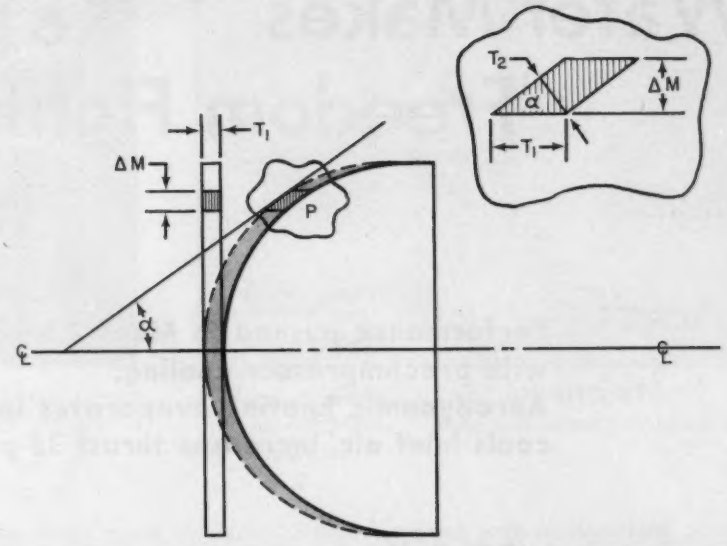
$\therefore T_2$ at point P = T_1 Sine α

The percentage reduction (R) at any point (P) is:

$$R = 100\left(1 - \frac{T_2}{T_1}\right)$$

$$\text{or } R = 100\left(1 - \frac{T_1 \text{ Sin } \alpha}{T_1}\right)$$

$$\therefore R = 100\ (1 - \text{Sin } \alpha)$$



TRIGONOMETRIC SINE-LAW relationship is used in power shear-spinning. Metal displacement is parallel to rotation centerline. Axial thickness remains unchanged; final wall, at any point, must equal blank thickness times sine of angle between rotation axis and tangent to surface at that point.

Monarch Lathe Co., guide the roller during spinning.

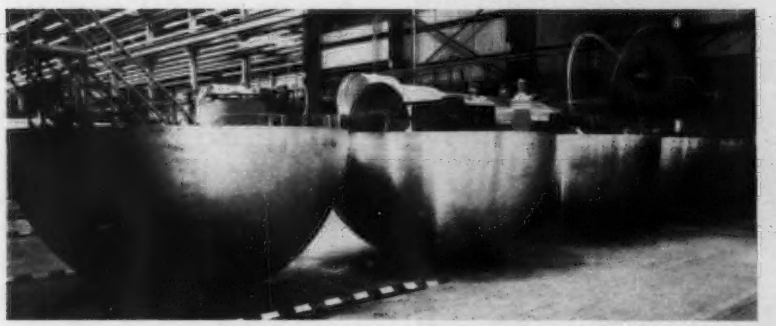
The two preform and one final form mandrels were made of cast iron, and machined on converted boring mill at ABMA. Physical limitations of modified machine dictated, to a degree, choice of preform design; therefore, subsequent machining of formed part was necessary to insure thickness tolerance control.

Blanks used in this second approach were 114-in. diam x 0.625 in. thick. Due to excessive thickness variations in the blanks as received, they were mechanically milled to an overall tolerance of ±0.005 in. This provided uniform response during spinning. Forming temperature was controlled throughout to 400°F maximum, using Tempil-Sticks.

- In the first preform, middle 82 in. of blank is flat and remainder is curved downward at about 35 deg. It is then degreased and annealed in preparation for subsequent spinning.
- Second preform mandrel increases the edge angle to about 55 deg; part is then 114 in. diam and 23½ in. deep. Again, it is degreased and annealed.
- Final shape of bulkhead is obtained by combining power shear-forming and conventional spinning. Power shear-forming is used until the part reaches an angle of 67½ deg to the vertical. Then by conventional spinning remainder of blank is spun onto mandrel.

Final metal thickness is obtained by machining off excess metal from convex side of bulkhead while it is held on final mandrel. A special device, using a roller to precede the cutting tool, forces the formed part against mandrel. Two templates are used in this machining operation. First is contoured to represent the final-stage mandrel plus the desired metal thickness of the bulkhead; a hydraulic tracer follows this template and guides the cutting tool. Second template guides the roller.

Mechanical properties of bulkhead are dependent upon the amount of cold working imparted to the aluminum alloy while it is on the final mandrel. Strength varies from ¼ hard near apex of hemisphere to more than ½ hard at the skirt. ✦



SPUN BULKHEADS, shaped in aluminum supplied by Alcoa, are shown in the fabrication and engineering lab, ABMA, before being welded into 70 in. diam cylindrical tanks clustered around a 105-in. diam center tank.

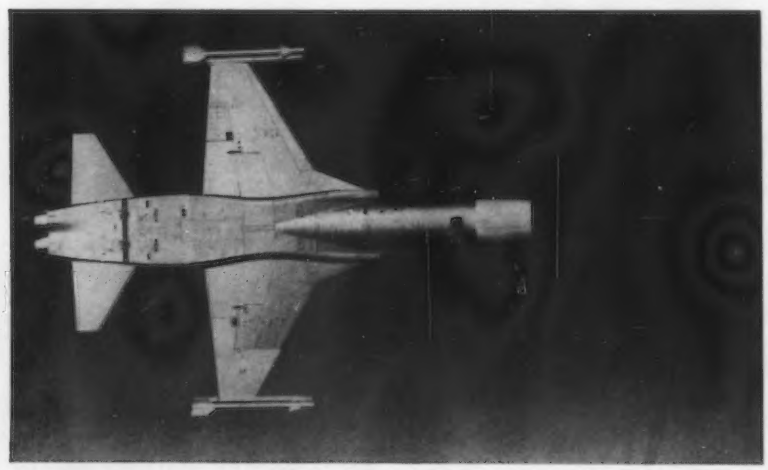
Water Makes "Freedom Fighter" Hotter

Performance pushed to Mach 2.1 with precompressor cooling; Aerodynamic heating evaporates injected H_2O, cools inlet air, increases thrust 33 percent

by Philip Geddes

Turbojet engine efficiency suffers at speeds above Mach 2. This can be traced in part to aerodynamic heating of air in the engine inlet ducts. At this speed, air in the ducts can rise to 250°F, even though ambient air is –66°F. The result is a decrease in mass flow . . . and, the effect is a serious loss of thrust, as pronounced as decreasing engine rpm.

Injecting a small amount of water into the inlet system has the effect of lowering the air temperature and increasing the mass flow. The process is called precompressor cooling. Cooling takes place through the evaporation process.



N-156F FREEDOM FIGHTER is a lightweight derivation of Northrop's T-38 "Talon" trainer. Both aircraft are powered by two J85-5 turbojets.

As the mass flow increases, thrust increases. Unofficial sources estimate thrust gains in the order of 45 per cent for a vehicle traveling at Mach 2.0 or better (Fig. 1).

The system differs from water injection schemes used to boost take-off thrust on hot days by requiring only 1/10 the amount of water. Take-off systems do not use evaporative cooling, so huge amounts of water must be used to increase mass-flow.

Airframe Limitations—But, the application of precompressor cooling to existing aircraft is limited . . . not by the margin of engine performance increase, but by the airframe configuration. Designers closely match the airframe to the performance of the engine when the aircraft is first designed. If major airframe changes must be incorporated to accommodate the increase in thrust and resulting increase in speed, the economics of the change might be questionable.

Mach 2.4 is the heat limit for the aluminum airframe. Accepting this limitation means there is little point in applying precompressor

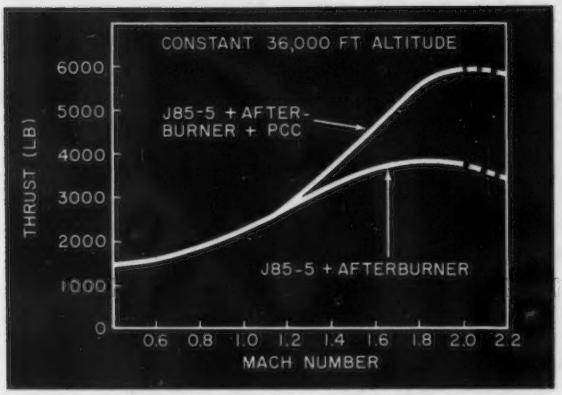


FIG. 1. THRUST GAINS obtained by precompressor cooling are estimated in the order of 45 per cent at Mach 2.0 flight speeds.

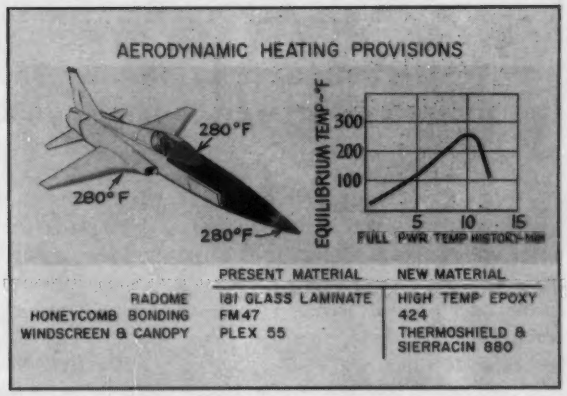


FIG. 2. STRUCTURAL MODIFICATIONS to N-156F effected by pushing performance to Mach 2.1 are summarized.

cooling to an aluminum aircraft already capable of near that speed.

Freedom Fighter Ideal — The N156F is a light-weight fighter derived from Northrop's T-38 "Talon" trainer. Both aircraft are powered by two J85-5 turbojets. Each engine delivers 2500 lb static thrust, rising to 3850 lb with afterburner. Total engine weight is 525 lb each.

When the fighter was in initial design, the J85 also existed only "on paper." The upper design limit for airframe performance allowed for normal engine development growth. Such growth, reflected in increased thrust, would upgrade airplane performance without structural modification. The N156F's top design speed of Mach 1.5 was therefore pegged to the thrust limitation of the early engines, not to potential airplane performance. When General Electric studied the possibility of applying precompressor cooling to the J85-5, they found the N156F airframe ideally suited for such a modification. It should be pointed out that the limiting factor in applying precompressor cooling to an engine is the upper temperature limit of the compressor and turbine stages. No redesign is necessary on the J85-5. For the higher mass flow, Norair designers were naturally delighted at a modification which could boost performance more than 33 per cent. In effect, the fighter was given bigger engines without disturbing advantages of the existing design.

The structural modifications to the N156F brought about by pushing performance to Mach 2.1 are shown in Fig. 2. Fortunately for Norair, the changes, other than inlet duct redesign, are in materials and processes rather than basic design shapes.

Flight Control System — The present flight control system is considered adequate for Mach 2.1. Norair's aerodynamicists say the airplane will be controllable at the new top speed, even with complete loss of longitudinal and directional augmentors.

continued on next page

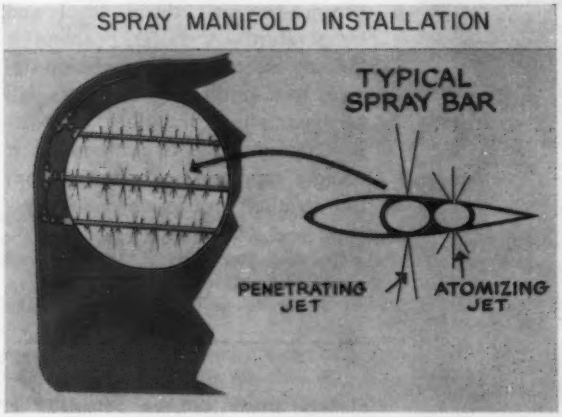


FIG. 3. SPRAY BARS in inlet ducts are well forward of engine intake. Bars have airfoil cross section and two rows of inset spray-nozzles.

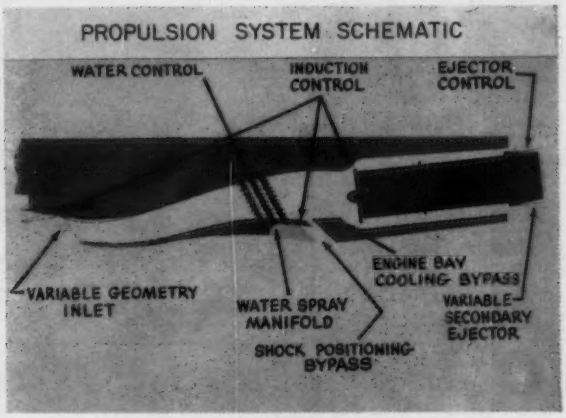


FIG. 4. VARIABLE GEOMETRY inlet system remains fixed to speeds up to Mach 1.5, and becomes infinitely variable at higher speeds.

Water fed to spray bars by 350 psi pump; Entire system weighs less than 200 lb

Weight Penalty—Weight penalty for the cooling system is slight compared with the gain in performance. 350 lb of fuel is replaced by 450 lb of water. Hardware in the precompressor cooling system weighs less than 200 lb.

Norair feel that the minor loss of range through the loss of fuel is offset by the higher dash capability in a maximum power intercept mission. The dorsal water tank and associated plumbing is designed to make sure of simple ground flushing procedures. In this way, either water for a high speed mission or fuel for an extended range mission may be carried.

Water System—The water for precompressor cooling is air pressure fed from the tank to an engine driven pump. The pump in turn supplies, at approximately 350 psig, two sets of spray bars located in the inlet ducts well forward of the engine intake. The spray bars are of airfoil cross section with two rows of inset spray nozzles (Fig. 3). These nozzles must be positioned to provide uniform temperature and pressure drop across the complete engine compressor face.

Ducting System—The existing inlet ramp on the N156F is designed for efficient pressure recovery up to Mach 1.5. While the present ducts are inefficient above Mach 1.5, a fixed duct design for Mach 2.1 compromises pressure recovery in the subsonic speed range. The solution is a variable vertical ramp inlet system, fixed to speeds up to Mach 1.5 and infinitely variable after that. (Fig. 4.)

The position of the vertical ramp at the inlet duct at a given speed determines pressure sensed at the engine inlet. Since engine rpm determines the quantity of air used, variations in rpm cause pressure variations in the duct system. Shock pressure build-ups in the ducting rise rapidly to explosive force which can cause disastrous failure. To preclude the possibility of shock explosions, it is necessary to include a pressure spill in the duct design in the form of a variable positioning bypass door with additional spill doors near the engine compressor.

The spill system dumps 5 per cent of the total engine air when in the median position. Bias of plus or minus 5 per cent about the 5 per cent spill allows an adequate tolerance for anticipated duct and engine transients, including a factor of safety. The spill pressure system is capable of passing 50 per cent of total duct air, since when high sudden loads are experienced, the doors will blow wide open. Spill air flows into a manifold around the engine inlet and exhausts downwards out of the airplane to provide additional lift at high speeds. Actuators move the vertical inlet ramp at a slower rate than the spill system, since the inlet change need be no faster than the airplane's ability to accelerate.

Controls—The inlet duct control system was designed by Marquardt Corp.

Mach pressure transducers sense inlet duct Mach number and temperature (Fig. 5). The cooling water injection system is metered to engine control sensing—water is injected in the ratio of 0.5 lb of water to 1 lb of fuel (approximately 1/10 of the amount of water injected for convential takeoff water injection).

The complete precompressor cooling system with controls, forms a closed loop between the engine compressor and thrust level and temperature. A design problem is holding electrical and electronic devices to a minimum—actuators will be pneumatic or hydraulic. In Norair's opinion, the precompressor cooling represents a complex loop, but definitely not an unreliable system.

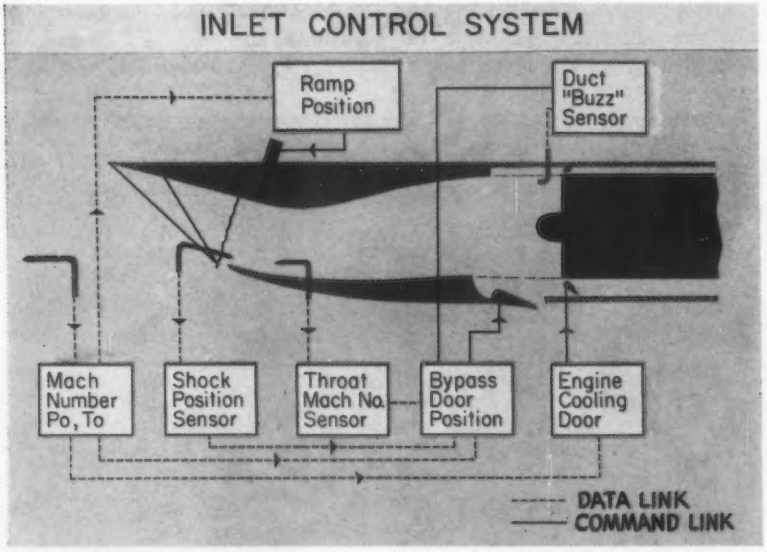


FIG. 5. CONTROL SYSTEM for inlet ducts was designed by Marquardt. Complete precompressor cooling system forms a closed-loop between engine compressor, thrust level, and temperature.

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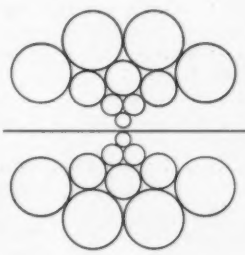

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Important facts to know about Laminated Plastics

LAMINATED PLASTICS *What they are, where they can be used*

Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

Types of laminated plastics made by Taylor
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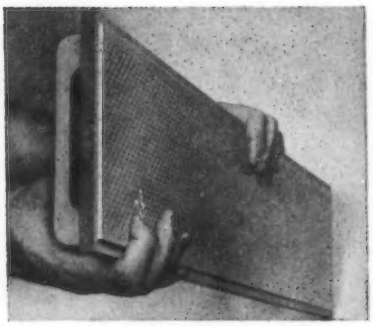
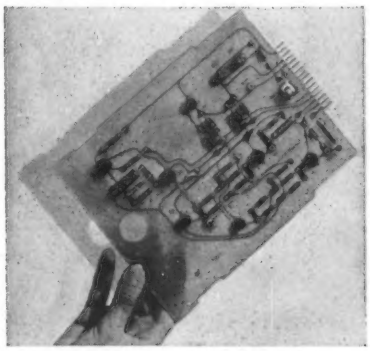
Phenolic Laminates. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

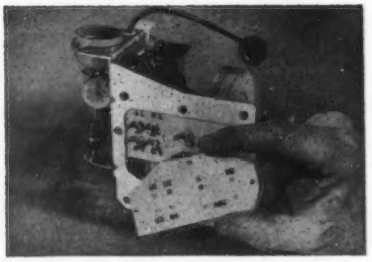


Melamine Laminates. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



Silicone Laminates. Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

Epoxy Laminates. Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

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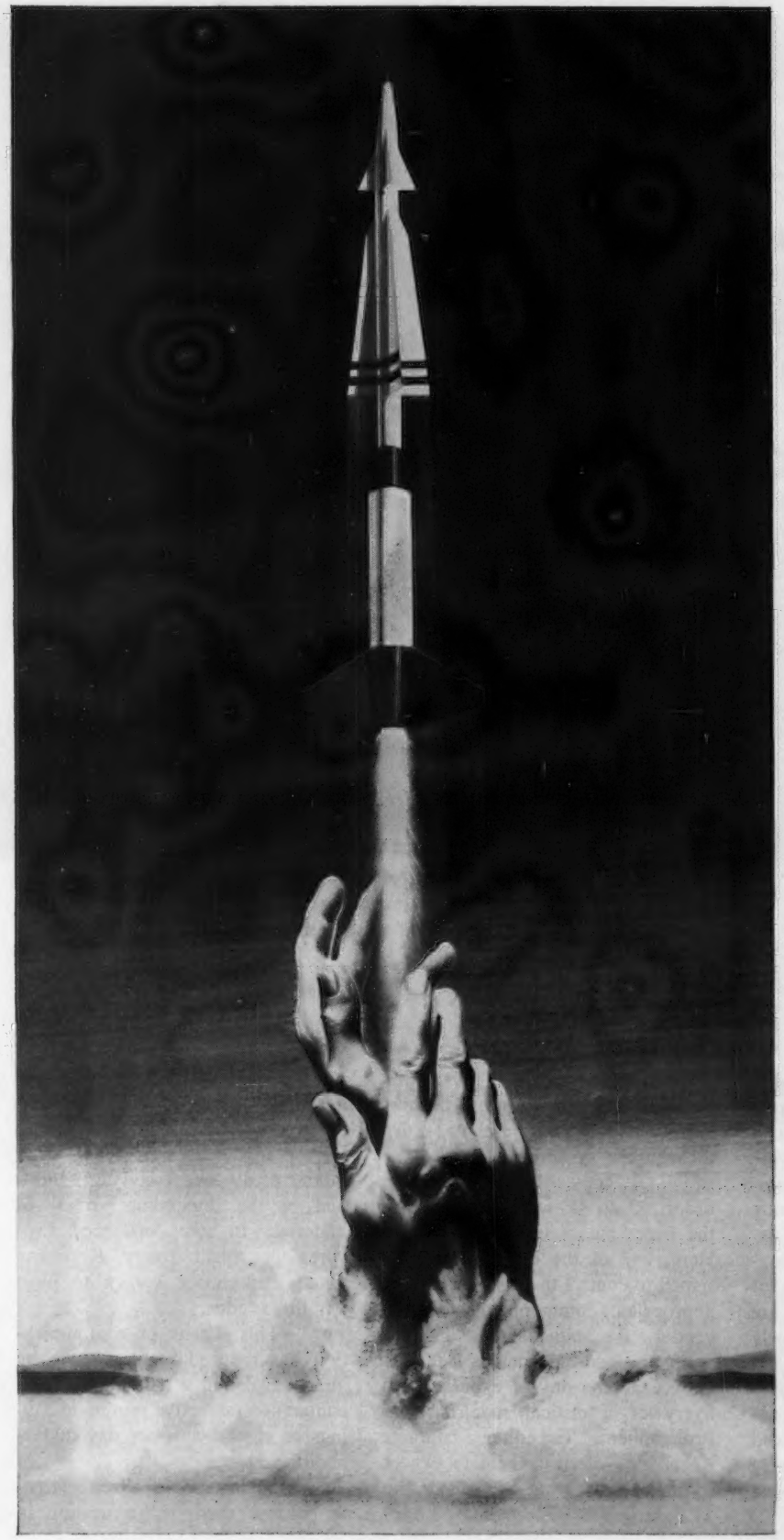

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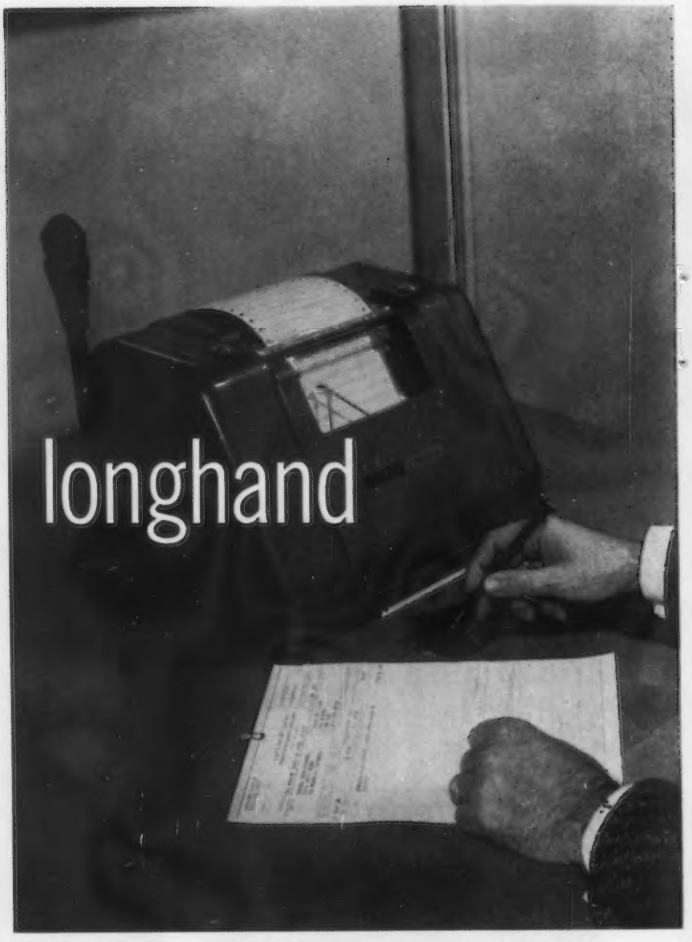
How Hughes speeds critical R&D materials through procurement and receiving with "streamlined" communications based on . . .

Electronic longhand

by W. W. Whitaker
Systems and Procedures Analyst
Hughes Aircraft Co.



PROCUREMENT EXPEDITER transmits TELautograph messages to Receiving Department to indicate shipments scheduled for current arrival.

The use of electronically-transmitted hand-written messages has doubled the working capacity of the Expediter in the Receiving Group at Hughes Aircraft. Streamlining communications has greatly simplified the task of getting materials vital to research and development programs into the hands of engineers. Many of the projects are critically dependent on this timely distribution of material.

Because of the faster transmission of information within procurement, departments which placed these "critical orders" now receive the materials an average of one and a half days sooner.

To understand how this saving is effected, it would be best to follow a typical purchase order through the system:

A copy of each purchase order R & D writes is sent to the Procurement Expediting group. Here, one of the expediters is assigned to control the order. Through appropriate communication to the vendor, the expediter is able to verify the expected delivery date.

On the day of expected delivery of a critical material, the Procurement Expediter contacts Receiving—alerting them to expect shipment—on what is called the TELautograph Electronic Longhand equipment. As he writes with a stylus, the message is automatically copied, in writing, on a telescriber in Receiving. Thus, in a matter of 30 sec, Receiving is notified of the impending arrival of material. In some instances, Procurement might query Receiving about a shipment known to have left the vendor.

This means of communication has reduced message time by almost two and a half minutes per contact—an effective minimum savings of eight hours per day in Expediting alone.

Saving is realized largely because there is no waiting in

EXPEDITING CLERK in receiving area removes message from telescriber, using it as a work ticket.

TELautograph Instan-Form is used to locate urgent shipment.

transmission of message by TELautograph. The procurement expediter merely goes to the telescriber and transmits the information which Receiving needs. Transmitting the same information by voice would tie up someone at the receiving end to write down the information. Then, after the message was recorded, it would have to be read back for verification.

The Receiving Expediter removes the written request from the machine and makes a visual check of the receiving area. Upon completion of the check, he transmits the appropriate answer to Procurement . . . "material not received," or "in process."

Receiving checks each dock three times a day for "critical" material. Upon spotting a shipment, Procurement is notified via the telescriber. At the same time, the expediter places the shipment in process to ultimate delivery point.

On receipt of "in process" notification, Procurement contacts the appropriate engineering lab, alerting engineers to imminent arrival.

Previous to the new communications setup, engineers in need of materials used the telephone to call either Receiving, Procurement, the buyer, or the vendor. This caused unnecessary calls and duplication of effort.

The new technique permits channelling all inquiries to the Procurement Expediter, who maintains a ready reference record on the progress of all orders. This places the information for answering engineering requests in immediate availability. In contrast to the normal frequency of 150 messages per day in the past, present rate of contacts is approximately 60 per day.

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Diesel Ramjet Design

New approach proposed by Armstrong Whitworth Aircraft departs from conventional circular venturi; Octagonal shape to cause multiple-shock flow and effect ignition by compression

by Ronald A. Cole

Considerable theoretical and practical work is being done in Europe on ramjets. Most of the big engine companies are making surveys, and several designers have considered ramjets for the next generation of big transports. Some advanced projects envisage integration of the ramjet with the wings of very high speed aircraft. An interesting development seen in France is the compound turbo-ramjet, an example of which has been flying for about two years. This consists of a standard turbojet mounted as a central pod in a ramjet duct. When both are working there is a mutual matching of airflows across the speed range and very high thrusts are developed. Speeds above Mach 2 have been attained with a purely research aircraft and very high altitudes have been reached.

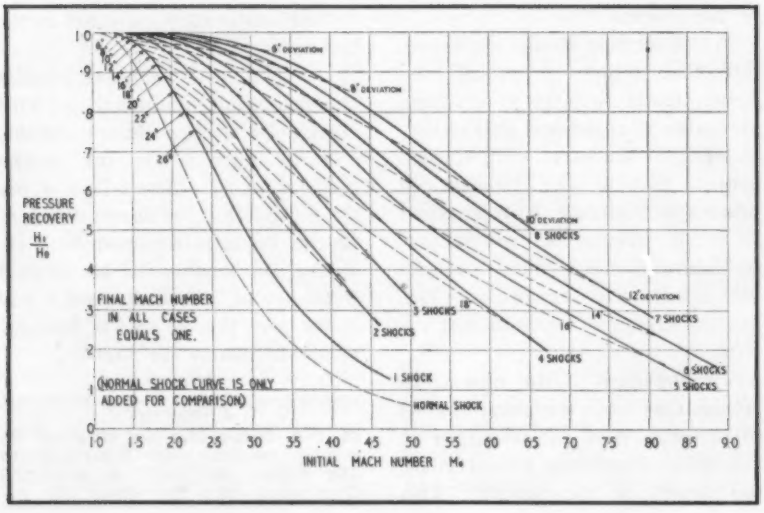
Generally, development thus far has been centered on units of conventional design. In these, air is slowed to subsonic velocities before it reaches the combustion zone. Air is slowed by a two-shock system at the intake, and finally by a flame holder. Flame will not propagate at speeds in excess of Mach 0.4 and the problem of slowing supersonic airstreams provides a limitation of design and operation.

Ramjet Transfiguration — Recently Dr. W. F. Hilton of Armstrong Whitworth Aircraft described a new approach to ramjet design, to make them suitable for very high speed flight. He explained how this would remove many of the present limitations, and simplify construction. Such improvements could make them also suitable for use as second-stage propulsion for large rockets.

New principle upon which Dr. Hilton's team had based their studies was that of spontaneous ignition of fuel by shock heating. This would make it unnecessary to slow the internal flow to subsonic values, hence would eliminate flame holders. Because of supersonic flow throughout the length of the motor the stream would be under much better control. Unpredictable variations due to shock wave and subsonic boundary-layer interference would not occur. On the basis of present calculations at Mach 5 a pressure recovery of 50 per cent may be possible.

To obtain good pressure recovery at high Mach numbers the air must be compressed in a multi-stage process. This could be done by passing it through several shock waves. A plot of pressure recovery against free-stream Mach number for various flow deflections and shock compression stages is given in adjacent graph. It is seen that

Pressure Recovery Across Oblique Shocks of Equal Deviation Angle vs Initial Mach Number ($\gamma = 1.4$)



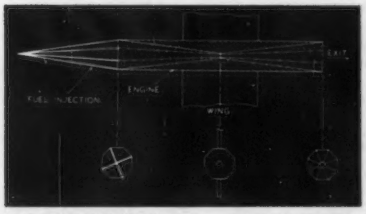
for best recovery more shock stages are needed as speed increases.

A relatively simple way of obtaining multi-shock compression is to adopt certain cross sectional shapes for the duct. In fact, there is an optimum shape for each speed-range. This theory has been developed from the following simple reasoning.

Consider air passing through a simple two-dimensional venturi. On its way through, air will pass through two shock waves. One which springs from the sharp leading edge and extends back to a focus point where it meets the shock from the opposite leading edge. The second shock is a limb extending from the focus to the venturi throat where Mach unity prevails. If this arrangement is repeated in the vertical plane, to make a four sided duct, then every streamline except the axial one, will pass through four shocks on its way to the throat.

Octagonal Cross Section — Extension of this linear law shows that an eight sided duct is needed to give eight-stage shock compression —the requirement for good pressure recovery around Mach 5 or 6. Although an octagonal duct approaches an infinite sided or circular duct there is a great deal of difference in their mechanics. A circular section will produce shocks which focus on the axis and give normal Mach intersection. In this way the flow is reduced to the normal two-shock system now in use and which is wasteful.

Several intrinsic features may make the compression ignition ramjet a very practical unit. The shock system will give a central concentration of heat and pressure about the major axis. Combustion will be contained in a shell formed by the shock waves themselves. Provided the flow is always supersonic, this shell or box, can contain pressures of hundreds of pounds per in.^{2} without the pressures reaching the duct walls. Likewise there will be good temperature insulation because of the thick layer of air moving between the combustion box and the walls. Both of these features will assist toward very light construction.

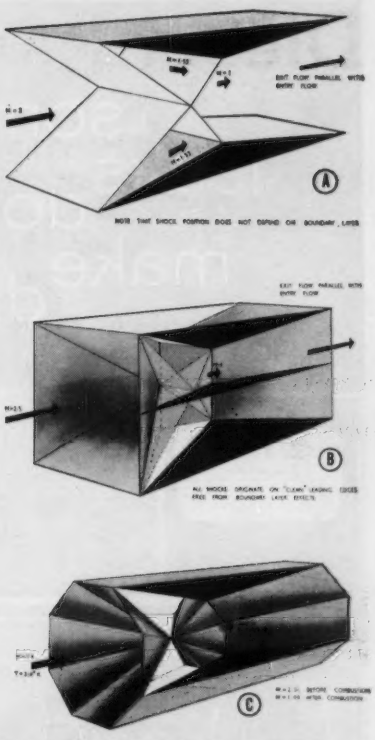


COMPRESSION - IGNITION RAMJET is shown in cross-sectional diagram.

Once past the minimum section of the duct air would be speeded up in the diffuser, and pressure acting on the walls would provide propulsive thrust. In the design of this type of engine the combustion delay period of the fuel is an important parameter. For kerosene, a millisecond delay may be expected; at typical speeds this would mean combustion taking place about 5 ft behind the shock focus. Since the airspeed in that region will be about 5000 ft/sec, getting fuel spread right across the flow will be a major problem. A spray bar arrangement ahead of the actual intake may be a solution.

Ignition by Compression—Specimen calculations give an indication of the pressures and temperatures likely to be attained in such engines. To provide automatic ignition of kerosene, an initial temperature of 1000°C is necessary; this will have to be provided by shock compression. It is anticipated that after combustion, gas temperature will be about 3000°C. Pressure generated by the multi-shock compression will be 315 atmospheres.

On the basis of these properties an engine designed for optimum use at Mach 7.4 would be about 4 ft across and 32 ft long. However, at lower speeds than this the temperature to ignite kerosene would not be generated. But, other safe fuels with a millisecond combustion delay are available, and these will ignite at temperatures as low as 700°C. These would permit operation of ramjet down to Mach 6.3, below this, there would have to be a change of geometry to give subsonic internal flow.

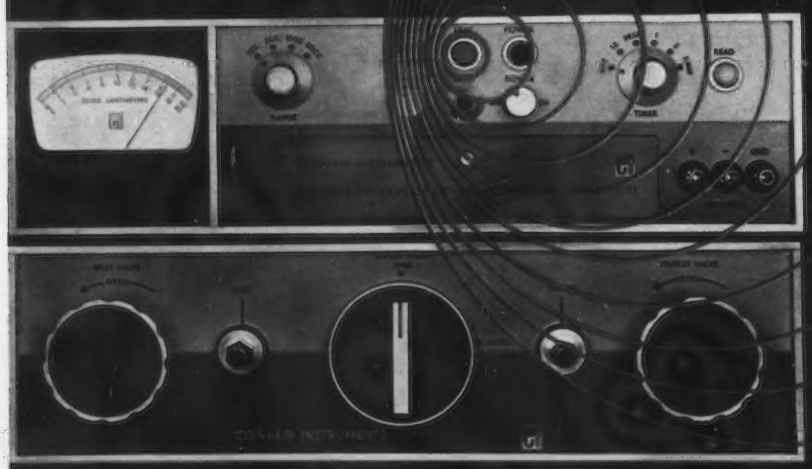


FLOW CHARACTERISTICS of flat-sided venturi configurations are illustrated. (A) In the two-dimensional flow through a basic venturi, each streamline (except that on central axis) will pass through two shocks. (B) In a four-walled venturi, each streamline will pass through four shocks. (C) In an octagonal venturi, eight-shock compression will result. Ignition will take place in the front prism by compression heating.

Although all the quantities envisaged represent formidable engineering figures they do not demand excessive power plant weight. This is because of the intrinsic combustion shell formed by the shocks themselves. It is thought that the duct walls may be constructed of sheet steel of a nominal 0.05 in. thickness. A unit 32 ft long would weigh some 1150 lb dry and would provide storage space for fuel between the inner and outer walls. Possibly a capacity for 11,000 lb of fuel may be provided, and this may serve as a useful heat sink.

✦

some leaks don't make drops



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New Materials

Fuel Cell Material

Dragon-Kote is a new Teflon-containing material for fuel cells. It is formulated specifically to cope with temperature extremes, corrosive characteristics and other problems involved in the safe handling of liquid propellant fuels and oxidizer systems. It has lowest permeability of a known film, and withstands 450° F.—Chemgineers, Inc.

Circle 60 on postcard for more data

Propellant Binder

Solid propellant rocket binder combines high performance of hydrocarbons and the superior processing and broad performance characteristics of polysulfides. It has low temperature flexibility, and resistance to aging at high temperatures. Designated C-12, binder has a very high percentage of hydrocarbon; this improves specific impulse.—Thiokol Chemical Corp.

Circle 61 on postcard for more data

Do-It Yourself Carbides

High-temperature carbide parts and tools can now be produced right in your own shop. Only conventional tools are needed to machine Ferro-Tic S, a new line of steel-bonded carbides. They are available as S-45 and S-55. Both are produced by powder metallurgy techniques, embedding tiny crystals of extremely hard titanium carbide in a relatively soft matrix of stainless steel. The difference between the two grades lies in their relative machinability, one having a hardness of approximately Rc 45, the other Rc 55.—Chromalloy Corp.

Circle 62 on postcard for more data

Rocket-Tested Cermet

Cerametalix, a high temperature material, has withstood a series of subscale and full scale solid rocket firings on one of the largest, hot-aluminized solid-propellant motors. Material showed zero throat erosion. It is a tungsten base compound approximately 25 per cent lighter than the pure metal.— Bendix Products Div.

Circle 63 on postcard for more data

Stainless Maskant

A new maskant or masking solution for chemical milling of stainless steel will resist etchant attack for 8 hr at 140°F. It may be either dipped or sprayed to form a tough, pliable, rubber-like film thickness of 10 to 12 mils. After etching, maskant can be easily and quickly stripped by peeling it off in large strips or sheets.—Rinshed-Mason Co.

Circle 64 on postcard far more data

Piezoelectric Ceramic

Ferroelectric ceramic elements compounded from "Michelite," a modified lead zirconium titanium material, maintain piezoelectric properties up to 350°C. Earlier materials were operable only to 100°C. "Michelite" also is suitable for cyrogenic temperatures, and is free from annoying transition points falling in between operating temperature limits. Elements have the highest coupling coefficients and sensitivities of any synthetic piezoelectric ceramic materials. Elements operating in a resonant mode can be made approximately 20 per cent smaller than conventional ceramic bodies.—Universal Dynamics Corp.

Circle 65 on postcard for more data

Fluorosilicone Sponge

COHRlastic is a new fluorosilicone sponge rubber compound with a dense, uniform, non-absorbing closed cell structure. It provides outstanding resistance to fuels and lubricants at extreme high temperatures. In addition, it possesses immunity to aging, ozone and weather hardening, excellent dielectric properties and good compression set resistance.—Connecticut Hard Rubber Co.

Circle 66 on postcard for more data

Brush-On Epoxy

A new epoxy electrical insulation can be spray or brush coated over existing insulations. Material is up to 300 times more resistant to breakdown by cracking than some phenolics. It requires no heat to cure and has good resistance to moisture and chemicals.—Westinghouse Electric Corp.

Circle 67 on postcard for more data

Improved Fluorel

Highly - fluorinated elastomer rated for service above 400°F continues with the name "Fluorel" KF-2141, though performance is considerably improved. New version has a Mooney scorch rating almost three times that of the original product. The cured elastomer meets military specification MIL-R-25897A requiring a tensile strength that does not decrease more than 35 per cent after aging for 16 hr at 600°F. Due to 60 per cent fluorine content it is inflammable. It does not crack after 200 hr exposure to 150 ppm ozone.—Minnesota Mining and Mfg. Co.

Circle 68 on postcard for more data

New Books & Reports

THE SOVIET AIR & ROCKET FORCES. Edited by Asher Lee. Praeger, 1959, 311 pp. $7.50. An up-to-date evaluation of Russian strength in the aerospace domain, by American, British, German, and Russian experts. Each of the 19 chapters presents a study on a specific aspect or era of Soviet Air Power, extending from the Tsarist Regime to the present; the closing chapter appropriately treats of "The Future of Soviet Air Power" which influences the formulation of Western defense policy today. The following authors contribute: Hanson W. Baldwin; Dr. Raymond L. Garthoff; William Green; Air Chief Marshal Sir Philip Joubert de la Ferte; Boris Kuban; Wing Commander Asher Lee; J. M. Mackintosh; Lieutenant George Schatunowski; General Walter Schwabedissen; Richard E. Stockwell; Kenneth R. Whiting; and Peter Williams.

SCIENCE AND TECHNOLOGY IN CONTEMPORARY WAR. By Maj. Gen. G. I. Pokrovsky (USSR), translated and annotated by Raymond L. Garthoff. Praeger, 1959, 180 pp. $4.00. These are the observations of a Soviet general, well qualified to speak on the subject by virtue of his participation in some of Russia's spectacular achievements in space. Although the major portion of this book is a discussion on technological progress, and the way it has influenced the methods of warfare through the ages, the treatment also contains the customary tribute to "dialectical materialism." Significantly, the majority of reflections made by the author center on technological innovations of Western origin. As such, the advances cited probably indicate what has influenced current Russian military thinking.

PROPULSION SYSTEMS FOR SPACE FLIGHT, by William R. Corliss. McGraw-Hill, 1960, 350 pp. $10.00. Major propulsion concepts for flight beyond the atmosphere are described and assessed from point of view of various missions.

THE NUCLEAR ROCKET: NEW POWERPLANT FOR SPACE VEHICLE PROPULSION. By Lt. Col. Howard R. Schmidt and Major Ralph S. Decker, USAF. 1960, 39 pp. This paper is an attempt to survey in a fundamental and practical way many of the aspects of nuclear rocket propulsion pertinent to early space-vehicle application. The nuclear rocket is discussed in terms of its basic cycle, technical program status, and its possible performance advantages. Available from OTS, Department of Commerce, Washington 25, D. C. Price: $0.50.

BASIC RESEARCH RESUMES — A Survey of Basic Research Activities in the Air Research and Development Command. Herner and Co. for ARDC. Dec. 1959. 342 pages. Order PB 161291 from OTS. $5.00.

NEXT MONTH

Look For These Exclusive Feature Articles

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GUIDANCE and DATA COLLECTION!

• The State of Airborne Inertial Guidance—A comprehensive survey of where we stand and where we are going with our most sophisticated, working guidance systems.

• PCM and The Minuteman—Thiokol's Utah Division uses a unique data collection system produced by Radiation Inc. in testing solid propellant rocket motors for Minuteman. It operates on the Pulse Code Modulation (PCM) principle. Why did Thiokol select PCM? How does the system work?

• Conflicting Demands In Radome Design—Electromagnetic windows which protect missile-borne guidance and data collecting systems present many problems to designers. The solutions reached are compromises in electrical, aerodynamic, and structural demands.

• Is Red Tape Driving Small Business Out of Defense Work? AIRCRAFT & MISSILES offers its editorial pages as a sounding board for controversies plaguing the aerospace industries. Next month Mr. Denham Scott, Garrett Corp., tells how well-intended procurement regulations to protect small business are actually "scaring-off" the small specialist.

New Parts and Components

Cooling Systems

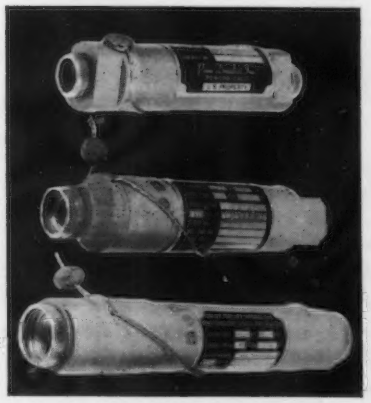
Four types of infrared detector cooling systems are available with the following features: (1) integrally mounted cell; (2) liquid feed —vacuum insulated line; (3) liquid to high pressure gas generator; and (4) liquid feed—uninsulated line. Detector cells of each system are cooled by heat exchange with liquid nitrogen, at –320°F. Within the integrally mounted cell system, direct contact between a container of liquid nitrogen and the cell is maintained by a heat conducting material.—Linde Company.

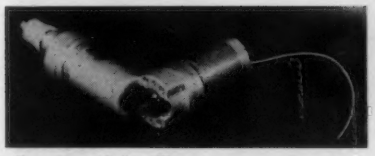
Circle 69 on postcard for more data

Relief Valves

Hydraulic relief-valves for auxiliary power systems feature low pressure spread, and negligible hysteresis for close pressure control. Response exceeds servo-valve response, and eliminates high pressure response accumulator. Valves are available in in-line and cartridge configurations. In-line valves, designated MS 28893, conform to MIL-V-8813 (ASG) specifications. —PneuDraulics, Inc.

Circle 70 on postcard for more data





Gyro Air-Pump

Designed primarily to supply air bearings on a gyroscope, pump operates by piston action of internal bellows. Recirculating air supply prevents introduction of external contamination. Model BK 1692 pump has a 2 psig pressure increase at a delivery rate of 2 liters/min. Models are available for 200-V 400-cyc current or 115-V 6-cyc current.—Breeze Corporations, Inc.

Circle 71 on postcard for more data

Missile Camera

A midget camera mounted in missiles at Woomera, Australia, records details of target interceptions.

Weight: 8 oz, 1½ in. in diam, 1¼ in. long. An ultra-wide-angle lens gives a field of view of 186 deg, so that two cameras mounted back-to-back give complete coverage through 360 deg. Shutter operates by firing an electric fuse; only one photograph can be taken. This is recorded on a disk of film 0.93 in. in diam, stamped out of standard 35 mm film lengths. Effective relative aperture is about f8 and a 2X yellow filter is included in the system.—Fairey Aviation.

Circle 72 on postcard for more data

Solid Gas—Generator

Compact, solid—propellant gas generator develops sufficient hp to generate electrical power for driving hydraulic systems on Navy's Tartar and Terrier missiles.

A boost disk of fast-burning propellant, cemented to starting end of main charge, provides the instantaneous burst of power needed to start the hydraulic and electrical system turbines within 0.8 sec. The storable propellant leaves no detrimental deposit on turbine blades. The compression-molded boost disk uses a combination nitrate-perchlorate oxidizer. Cool-burning main stage propellant is adaptation of ammonium-nitrate propellant used in the M15A1 JATO. — Rocketdyne.

Circle 73 on postcard for more data

Hot-Gas Relief Valves

Special-purpose pressure-relief valves prevent buildup of pressure in solid - propellant combustion-chambers, and control the burning rate. A typical valve model passes 0.015 lb of gas per sec, operates at a combustion-chamber pressure of 1200 psi, and at 2000°F. Valves are made to suit specific operational and dimensional requirements.—Aero Supply Mfg. Co.

Circle 74 on postcard for more data

On production and maintenance work in manufacturing and service industries, Apex screwdriving tools have helped cut fastening costs for large and small companies alike. There's an Apex screwdriving tool to drive just about any kind and size of screw-type fastener . . . for use with any popular make of power or manual driver. All Apex Standard and Magnetic Screwdriving Tools are listed in Catalog 30-C; write, on your company letterhead please, for your copy.

APEX FASTENING TOOLS

SCREWDRIVING • NUT RUNNING • SPECIAL

New Parts and Components

Miniature Gyro

Miniature electric free gyro, designated Type PHU, has 2 deg of freedom. It is 2.0 in. by 2.5 in., weighs 250 grams. Scorsby Drift is 1 deg per minute maximum, with outer gimbal readout. — Greenleaf Manufacturing, Division of Mandrel Industries.

Circle 75 on postcard for more data

Instrument Regulator

Instrument regulator weighing 7½ oz is of all-stainless construction. It features all metal-to-metal seals and one moving part. The pneumatic static pressure regulator can withstand temperatures to 1000°F. Regulated pressure is adjustable from 2 psia to 17 psia, and is ±0.1 psi at set pressure at temperatures ranging from –65°F to 600°F.—Gladden Products Corp.

Circle 76 on postcard for more data

Non-Drip Oil-Nozzle

Number 8385G filler nozzle for commercial aircraft has a 13-in. tube with a positive shut-off, non-drip valve in its outlet opening. The nozzle comes complete with inlet check valve, dust cap, and 20 mesh reinforced strainer which is easily removable for cleaning. Nozzle weighs 7 lb.—Buckeye Iron & Brass Works

Circle 77 on postcard for more data

Free Gyro

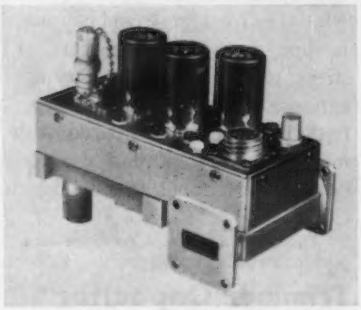
Model Q2315 two-degree-of-freedom gyro utilizes a.c. synchro transmitters located at each gimbal axis to provide extremely accurate angular displacement information. Torquers mounted at each gimbal axis permit command positioning or slaving of spin axis to desired reference position; each torquer is capable of a precession rate of 360 deg/min with 12.5 watts/phase power input.—Kearfott Company

Circle 78 on postcard for more data

New Electronic Products

Mixer Preamplifier

Integrated mixer - preamplifier provides further coverage of X-band in a standard stock unit. Operating over the 10.5-12.4KMC



spectrum, the MMX-3 is gain stabilized, has a 20mc I.F. bandpass centered at 60mc, 25db minimum overall gain, and a 9db maximum noise figure.—LEL, Inc.

Circle 79 on postcard for more data

Strain Sensors

New whisker-sized semiconductor strain sensing element boosts sensitivity of strain gauges 50 times. Microminiaturized sensing mechanism is also applicable to transducer applications in the measurement of pressure, linear and angular acceleration and vibration. In strain measuring, the whisker boasts an ultimate gauge factor of 175 compared to less than five for wire strain elements now in use.—Electro Optical Systems, Inc.

Circle 80 on postcard for more data

Hi-Power TW Tube

A one - kilowatt traveling wave tube combines a periodic focused permanent magnet (PPM) with a gridded gun. This decreases response time and allows lower power consumption. Previous to this development, traveling wave tubes with magnetic focusing used a pulsed cathode to supply the beam and involved pulse levels of 5,000 to 10,000 V resulting in a difficult modulation problem. — Hughes Products, Electron Tube Div.

Circle 81 on postcard for more data

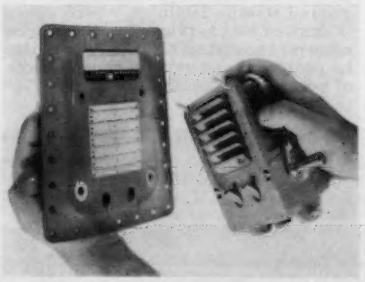
Electronic Photo Recon

Photoscan is an entirely new type of airborne electronic scanner. It processes the visual image obtained from an aerial camera or other sensing device and converts that image to an electronic signal. Signal is then transmitted to another airborne relay station or directly to specially designed receiving equipment on the ground. New electronic image enhancement techniques are applied to the signal before reconstituing the original image.—CBS Laboratories

Circle 82 on postcard for more data

Umbilical Connector

Umbilical connectors are small, lightweight, "automation" units. They feature a mating and unmating mechanism so that the whole



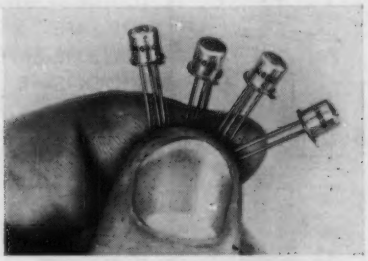
operation may be accomplished without use of tools.

Design provides for 300 individual contacts, each rated at 5 amp. All are mounted in a space 2¾ inches square. — Automation Electronics.

Circle 83 on postcard for more data

Tunnel Diodes

Gallium arsenide tunnel diodes are designed for specific applications in high speed computer circuitry.



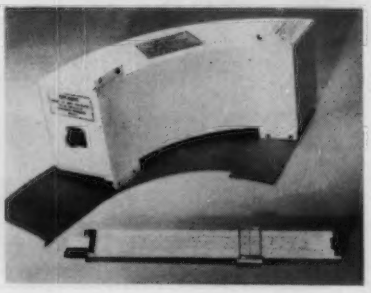
The 1N650 Series, packaged in the lightweight standard JEDEC TO-18 case, provides guaranteed peak currents up to 10 milliamperes ±2 per cent, guaranteed forward voltages up to 1.1 volts ±5 per cent, and high temperature operation up to 150°C.—Texas Instruments Inc.

Circle 84 on postcard for more data

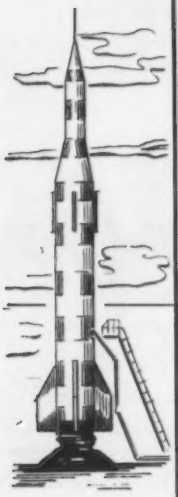
Contour Batteries

Silver - zinc primary battery, Model P58A, is for missile APU systems. It is an automatically activated 20-cell unit shaped to an 88 deg arc. Battery measures 11 x 5 in. and weighs 13 lb. With a capacity of 7 ampere-hours, it produces 14 amp at 28 volts. Maximum current is 50 amp. Discharge time is 30 min at 14 amp.—Cook Batteries.

Circle 85 on postcard for more data



1st CHOICE . . . NOW *and for the* FUTURE



BARCO FLEXIBLE JOINTS (*Gimbal or Swivel*)
FIRE-SAFE
PRESSURE-SAFE
SHOCK-SAFE
DETERIORATION-SAFE

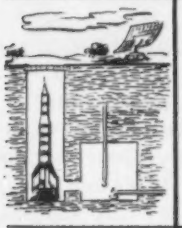
Barco is the leader in providing "Flexibility for Metal Piping" — the key to safety, permanence, and reliability wherever construction involves flow of fluids in missile launching, ground support equipment, or permanent base installations. Barco Flexible Joints are backed by years of successful engineering experience in this field and are available in sizes, styles, and types to meet current project requirements. Specify BARCO—NOW and for the FUTURE!

FOR MISSILE FUEL LOADING LINES

Barco "LOX" Joints meet requirements and have passed the official "qualification test" for handling cryogenic and other fluids used in fueling missiles, including liquid oxygen, nitric acid and other chemicals. Barco Joints for liquid oxygen are used for thermal contraction in piping and for making metal loading lines that are easily movable, flexible, and SAFE.

FOR HYDRAULIC ACTUATING LINES ON GROUND SUPPORT EQUIPMENT

Wherever hydraulic fluid is used to actuate movable parts of ground support equipment, any desired flexibility can be obtained with Barco Ball Bearing Swivel Joints installed singly or in "dog leg" assemblies in combination with metal tubing or pipe. Wide choice of designs approved for use.



FOR SERVICE PIPING IN PERMANENT LAUNCHING SITE INSTALLATIONS

Widely used to protect vital pipe lines against "shock", up to 50 G's or more, Barco Ball Joints also have broad application in building permanent underground missile facilities where space is limited and service piping must be allowed to expand thermally and also be protected against the shock effects of possible blasts. Choice of sizes ½" to 16".

ASK FOR RECOMMENDATIONS — We invite your inquiry and will be glad to provide engineering recommendations. Industry-wide sales and service. Literature on request:

Catalog 233A—"Flexible Ball Joints for Handling Liquid Oxygen and Missile Fuels."
Catalog 2698—"Plane and Self-Aligning Swivel Joints for Hydraulic Service."
Catalog 2158—"Barco Ball Joints for Flexibility in Piping."
Bulletin 31A—"Ball Joints for Expansion or Contraction in Fixed Piping."

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FLEXIBILITY FOR METAL PIPING
Serving Industry Since 1908

New Electronic Products

Mesa Transistors

New class of diffused silicon "mesa" transistors has been developed.

Advanced diffusion techniques are being used to produce two types. The NS200 is used for switching applications in computer circuitry. NS300 is for high frequency amplification in video amplifiers, I.F. strips, telemetering and other applications. Output capacitance of both is 5 mmfd, compared with a minimum of 6 mmfd for other types. — National Semiconductor Corp.

Circle 86 on postcard for more data

Trimmer Capacitor

Miniaturized trimmer capacitor offers a high degree of control precision. Outstanding features are: A non-rotating piston fitted into a glass cylinder whose internal diam is mirror finished, this virtually eliminates all air gap between piston and cylinder wall. The adjusting screw remains flush with the face of the bushing regardless of its adjustment. This eliminates the inconvenience of a projecting or recessed screw and the attendant fragility or chance of damage.—Atlee Corp.

Circle 87 on postcard for more data

"Shaped" Battery

A special, "shaped" electric APU power source containing two separate battery sections provides dual output. The two battery sections in the Model P68A also provide two different voltage levels. One section gives a current of 8 amp at 28 v. The second section supplies 6.3 V power at 3 amp. Both sections are activated automatically. The activating mechanism is a simple electrolyte tank and piston arrangement, operated by a solid propellant gas generator.—Cook Batteries

Circle 88 on postcard for more data

New for Production

Data Processing Unit

G-20 transistorized data processing system is called many times faster than other computers in the same price class. Larger than firm's G-15 computer, G-20 supervises auxiliary units which read punched cards, search magnetic tape, or print answers.—Bendix Aviation

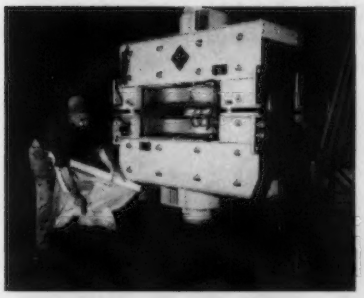
Circle 89 on postcard for more data

Temp Chambers

Temperature chamber tests missile/aircraft components in high and low temperature environments; and with vibration in all three axes.

Optional hydraulic lift makes the chamber (called TE-100) self-elevating for use over vibration exciters or oil-film vibration slip tables. Holes in the bottom of the chamber match attachment holes in vibrator heads.—Wyle Manufacturing Corp.

Circle 90 on postcard for more data



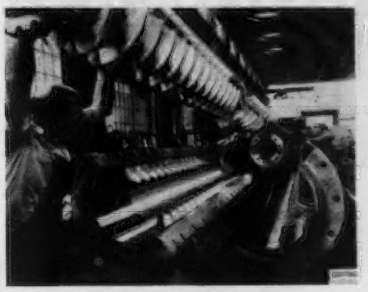
Solid Fuel Inspection

At least five solid fuel production or handling facilities are being supplied with 25-million volt betatrons. Reported advantages of this voltage (25-mev) X-ray inspection: time, ability to penetrate thicker sections beyond the range of other nondestructive test equipment.—Allis-Chalmers Manufacturing Co.

Circle 92 on postcard for more data

Mixing Machines

Continuous mixing machines in "Ko-Kneader" line are used in manufacturing rocket fuels, plastics. Stainless steel chamber holds a 16-ft. mixing screw. In operation the screw reciprocates and rotates between machined stainless-steel teeth.



Chamber has barrel appearance during operation. It opens hydraulically for cleaning (see cut).—Baker Perkins.

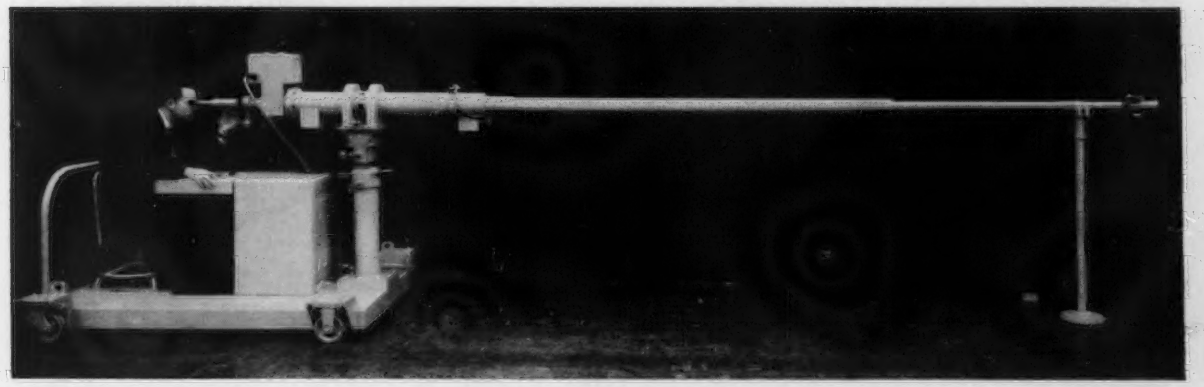
Circle 93 on postcard for more data

Rocket Private Eye

Optical inspection device is designed for solid rocket motors. It can also be used in a portable version to probe tanks, airplane wings, hard-to-get-at interiors. (Current versions can conduct a probe of 30 ft. with one insertion.)

Grain checker features a safe external light source, a mirror, driven along a slotted optical tube, and a specially-designed telescope which magnifies the image of the grain reflected by the mirror. It can inspect an opening down to 2 in. diam. with no practical limit on maximum diameter, and can be fitted with a camera.—Aerojet-general Corp.

Circle 91 on postcard for more data



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- NEEDLE VALVES
- ENGINE PRIMERS
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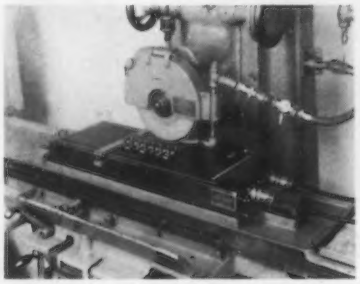
Circle 27 on Inquiry Card

New for Production

Electrostatic Chucks

Electrostatic chucking equipment applies electrostatic rather than electro-magnetic force for chucking small parts.



Any electrical conductor can be held on this type of chuck. It is also possible to chuck ceramics or plastics. Available in two sizes, with 6 in. x 18 in. or 5 in. x 8 in. working surface.—Electroforce Inc.

Circle 94 on postcard for more data

Camera

Movie camera can stretch events of one second into 28 hours. By combining optical, electronic and mechanical principles, it can take from 480 to 1,600,000 pictures per sec on standard 35 mm film, in black and white or color. Scientists and engineers may freeze motion while studying arc discharges, explosive reactions, fragmentation processes, high frequency fatigue and many other ultra-fast events.—Benson-Lehner Corp.

Circle 95 on postcard for more data

Magnetic Inspection

Magnetic particle inspection materials are now available in pressurized spray cans and plastic squeeze bottles. Materials may be used with inspection equipment or portable kits used in testing magnetic parts in aircraft.—Magnaflux Corp.

Circle 96 on postcard for more data

Performance pays off...

in aircraft, missiles and production tools

Screw Drivers

Pistol Drills

Grinders and Sanders

Right-Angle Drills

. . . and where missile and aircraft production line performance stands out consistently you're apt to find Airetool air powered equipment. Accurate and dependable, Airetool pneumatic production tools are engineered to deliver top-notch, 'round-the-clock production with little or no maintenance.

Learn the complete story on how Airetool can help boost your production line performance. Write:

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European Plant: Vlaardingen, The Netherlands
Canadian Plant: Brantford, Ontario

Circle 28 on Inquiry Card

Worth Asking For

Silver-Zinc Batteries

Bulletins describe primary and secondary silver-zinc batteries. *Cook Batteries*

Circle 97 on postcard for more data

MSVD

32 pg. bulletin PIBA-4 describes activities, products, facilities, and personnel of GE's Missile and Space Vehicle Department.—*General Electric Co.*

Circle 98 on postcard for more data

Space Facts

60 pg. handbook of basic and advanced space flight and environmental data. Called PIBD-3, it includes 14 tables, 44 illustrations.—*Missile and Space Vehicle Dept., General Electric*

Circle 99 on postcard for more data

Tracking Network

Illustrated outline of setup, operation of SpaN Net, world-wide space communication network.—*Space Technology Laboratories*

Circle 100 on postcard for more data

Indian Industrial Development

Department of Interior brochure describes industrial opportunities offered by Indian tribes and nearby communities. *Bureau of Indian Affairs.*

Circle 101 on postcard for more data

Heat-treating

Complete design breakdown of new automatic heat treating unit. *Ipsen Industries, Inc.*

Cirlce 102 on postcard for more data

Propulsion Systems

Two-color brochure features a comprehensive description of three major approaches to advanced propulsion and power conversion systems for space vehicles. *High Voltage Astronautics, Inc.*

Circle 103 on postcard for more data

Dialing Chart

Chart shows direct distance dialing telephone codes in use throughout U. S. and Southern Canada. *Ohio Seamless Tube Div., Copperweld Steel Co.*

Circle 104 on postcard for more data

Bolt Catalog

Catalog No. 600, guide to the selection of precision bolts and special fasteners. *Aircraft Bolt Corp.*

Circle 105 on postcard for more data

Power Supplies

Brochure on constant voltage power supplies with slope control. *Glenn Pacific Power Supply Corp.*

Circle 106 on postcard for more data

Aircraft Instruments

Illustrated 48-page manual—designated 05-100-B—describes a line of aviation instruments and components. *Weston Instruments Div., Daystrom, Inc.*

Circle 107 on postcard for more data

Molybdenum

Molybdenum mill products specifications booklet. *Refractomet Div., Universal-Cyclops Steel Corp.*

Circle 108 on postcard for more data

Structural Adhesives

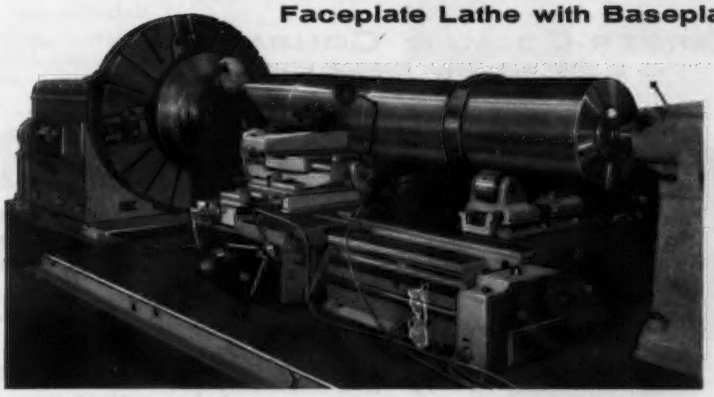
Catalog contains information on "SCOTCH-WELD" structural adhesives and structural adhesive design concepts, joint designs and bonding methods. *Minnesota Mining and Manufacturing Co.*

Circle 109 on postcard for more data

Unparalleled Versatility!

RAVENSBURG

Faceplate Lathe with Baseplate



Ravensburg Faceplate Lathe showing headstock, tailstock, steady rest, carriage and baseplate in working position. Note "Electric-Shaft" Drive (arrow).

The headstock and bed of Ravensburg Faceplate Lathes are separate units, with the tailstock traveling on special baseplate slideways. The bed can be positioned on the baseplate either perpendicular or parallel to the turning axis, or at any intermediate location. This ultra-versatility is especially valuable in machining large, relatively light workpieces; such as missile bodies or nose cones, and medium weight workpieces for generators and turbines.

The headstock has 12 to 18 spindle speeds. It can be equipped with a mechanical or electrical variator drive and constant cutting speed control.

Accurate feeding of the carriage, in inches per revolution, is obtained through a patented "electric-shaft" drive, which eliminates any mechanical linkage with the headstock, and permits independent positioning of the bed on the baseplate. The cross slide carries an upper slide which is mounted on a rotary base and feeds automatically in any direction.

Electric or hydraulic copying devices are available to meet specific requirements.

SPECIFICATIONS

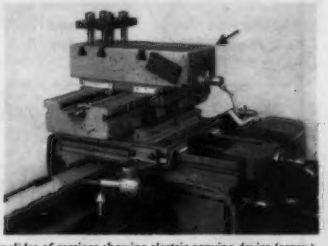
Center Distance—virtually unlimited!

Swing over Baseplate—110"

Max. Faceplate Diameter—138"

Five standard models—
many combinations from which to choose.

Special designs available upon request.



Upper slides of carriage showing electric copying device (arrow), Rotary base (arrow) and manually controlled tool slide.

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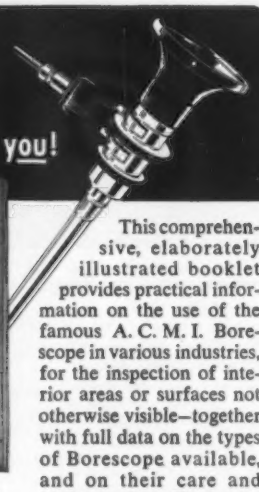
This booklet is for you!



This comprehensive, elaborately illustrated booklet provides practical information on the use of the famous A. C. M. I. Borescope in various industries, for the inspection of interior areas or surfaces not otherwise visible—together with full data on the types of Borescope available, and on their care and maintenance. Have you received your copy?

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Gentlemen: Please send me without obligation a copy of your booklet on Borescopes.

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Firm_____
Address_____
City_____ State_____

Circle 32 on Inquiry Card

Worth Asking For

REL

"Solutions Unlimited," story of radio electronic firm. *Radio Engineering Laboratories Inc.*

Circle 110 on postcard for more data

MIL Components

Catalog on components for military applications. Includes guide to identifying and ordering this equipment by military specs. *Ohmite Manufacturing Co.*

Circle 111 on postcard for more data

Machine Operation

Eight pg. brochure and 36 pg. operational manual on new line of single, twin and opposed spindle boring, turning and facing machines. *Industrial Machinery Div., American Electronics.*

Circle 112 on postcard for more data

Flame Spray

Engineering data on basic flame spray processes. *Metallizing Engineering Co.*

Circle 113 on postcard for more data

CASA

Brochure describes work and capabilities of association of subcontractors in aircraft and missiles. *Cleveland Aero-Space Association.*

Circle 114 on postcard for more data

Metal-Forming

Special products catalog describes, illustrates three new high speed forming machines. *The Cyril Bath Co.*

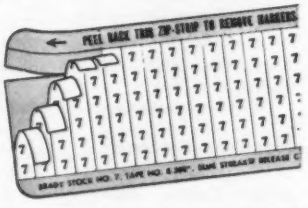
Circle 115 on postcard for more data

SHORT RUN OR MASS PRODUCTION

These self-sticking products for marking or masking help you get projects "off the ground" faster — whether prototype or production:

WIRE MARKERS

Identify wires, components, harnesses. The only wire marker that can be applied by hand or automatically—at speeds up to 1000 per hour. A marker for every size and type of wire.



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Made-to-order markers with any size, color, legends, wordings. 200 self-sticking materials.

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Pre-cut masks for painting, anodizing, vacuum metalizing, solder dipping.

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Manufacturers of Quality Pressure-Sensitive Industrial Tape Products, Self-Bonding Nameplates, Automatic Machines for Dispensing Labels, Nameplates, Masks and Tape • Est. 1914. 98

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Men on the Move

MAURICE R. VAN CAMP, appointed controller and assistant treasurer of North American Aviation.

DR. JACK SILVERMAN, promoted to chief in charge of chemistry; and DR. L. C. STRUCKENBRUCK, made chief of solid propulsion; at Rocketdyne's Research Subdivision.

JAMES D. STEWART, appointed manager of metal and plastics quality control inspection at Goodyear Aircraft Corp.

FREDERICK L. HALL, Director of Management Control at the Solid Rocket Plant of the Aerojet-General Corp. has joined the law firm of Wyman, Finnell and Rothman, Beverly Hills, Calif.

J. A. GORGENSON will be program manager for Douglas Skybolt development. VEARL CROSLEY will be assistant program manager.

SOLOMON CHARP, appointed manager of navigation and control electronic equipment for General Electric's Missile and Space Vehicle Department. F. E. RUSHLOW, appointed manager of Sales and Contract Management at the department. BROOKS F. BRICKLEY, appointed manager of foreign operations at General Electric's Flight Propulsion Div. SAMUEL J. LEVINE, named manager-projects for the General Electric Nuclear Propulsion Dept.

BENJAMIN H. CISCEL, appointed general manager of the Electronics Div., Chance Vought Aircraft.

STANLEY ABKOWITZ, appointed manager of refractory metals product development at the Metals Div., Kelsey-Hayes Co.

BEVERLY W. HODGES, appointed to the newly-created position of assistant chief engineer at Boeing-Wichita.

ALVIN B. GOODSPEED, promoted to director of sales at A C Spark Plug, Div. of General Motors. JOHN F. CARR, appointed director of contracts.

GEORGE S. TRIMBLE JR., named corporate Vice President for Advanced Programs of the Martin Co.; VERNON L. RAWLINGS, named director of a newly organized Manufacturing Division, O. E. TIBBS succeeds Rawlings as director of Titan activation, NICHOLAS M. VOORHIES, appointed director of Requirements, and JACK B. GILBERT, appointed quality control manager, all at Martin-Denver; RICHARD F. WEHRLIN, appointed director-general for international operations; ROBERT W. CUTHILL, named chief engineer of the Orlando Div.; JUSTIN L. BLOOM, named project engineer for advanced SNAP systems in the Nuclear Div.

J. J. KERLEY, promoted to vice president, Avco-Crosley. BERT FEIN, appointed director of manufacturing.

DANIEL C. MCCARTHY, named administrative vice president; GREGORY C. GATES, appointed purchasing manager, and WILLIAM G. GRAEBER, promoted to personnel director, at Pratt & Whitney Co.

CAPTAIN SHELDON BROWN, USN, (Ret.), appointed assistant manager of Aerojet-General Corporation's Atlantic Div.

JOHN A. SWINT, appointed director of operations for the Ogden Div., The Marquardt Corp.

S. E. DANYOW, appointed vice president, Rocket and Ballistic Operations of Rocket Power-Talco Div., The Gabriel Co. E. PAUL JACKSON, appointed marketing director, Eastern Region.

ROY N. CARLSON, appointed Aircraft Service Manager for the Bendix Products Div., The Bendix Aviation Corp.

J. P. FIELD, named staff assistant to the general manager; R. R. WENDT promoted to manager of quality and reliability; and WILLIAM SOLOMON appointed chief airframe engineer at Bendix Products Div.-missiles; S. B. SMITH, appointed assistant director of engineering.

George S. Trimble Jr.
Martin

Jack B. Gilbert
Martin-Denver

J. J. Kerley
Avco-Crosley

Bert Fein
Avco-Crosley

Daniel C. McCarthy
Pratt & Whitney

Capt. Sheldon Brown
U.S.N. (Ret.)
Aerojet-General

S. E. Danyow
Rocket Power—Talco

E. Paul Jackson
Rocket-Power-Talco

Roy N. Carlson
Bendix Products Div.

J. P. Field
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400° above to 110° below in minutes*

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...WITH PURECO CO_2 "BLAST COLD"

CO_2 is Best... For Test

The Pureco CO_2 *Blast Cold* process is a simple, efficient low cost method of refrigeration for low temperature test chambers. Direct injection of Pureco carbon dioxide liquid drops temperatures to required levels in a fraction of the time required by mechanical units. Cooling is produced by vaporizing a jet of liquified CO_2 directly into the chamber.

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Temperatures are automatically controllable within limits closer than government testing standards require. Pureco CO_2 *Blast Cold* starts immediately at maximum rate the instant valves cycle on—stops the instant CO_2 flow is cut off.

Low capital expense... low operating cost.

No heavy investment required for equipment . . . installation is simple and space saving. Equipment is trouble-free. There is virtually no possibility of mechanical failure.

Direct or Indirect Cooling.

CO_2 liquid may be injected or DRY-ICE placed directly in a chamber—used to cool a circulating air stream or a non-freezing solution for indirect cooling.

Have a trial Blast Cold demonstration.

Pureco would like to demonstrate *Blast Cold* to you at *your* plant under your working conditions, with no obligation on your part. Pureco's Technical Sales Service will provide any assistance you need to help solve your low temperature testing problems.

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AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT

Industry Notes

Restart AbleStar

AbleStar engine, in placing Transit 1B in orbit, became the first U. S. rocket propulsion system to be restarted in space.

Designed and fabricated by Aerojet-General and Space Technology Labs, AbleStar followed this second stage flight sequence:

First burning period: 4.3 minutes.

Engine shutdown and attitude-controlled coast period of 19 minutes.

Altitude restart of stage, which then burned for 13 sec., injecting satellite into orbit. Total burning time was longest of any U. S. propulsion stage.

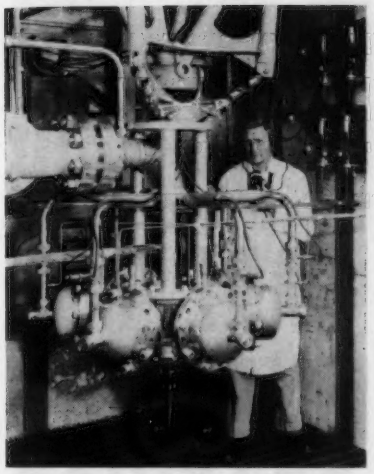
After second burning, payload was spun to about 130 rpm by a pneumatically actuated spin mechanism. It was explosively separated 17 seconds after spinning began.

AbleStar uses a pressure fed, liquid propellant system with a gimbaled, regeneratively-cooled, aluminum thrust chamber assembly.

AbleStar was used as second stage with Thor booster. Transit, protected by fiberglass nose fairing, was mounted on top.

Engineers' N.B.

Scientists and engineers are being encouraged to participate in Project CATE, an index of individual technical capabilities being compiled by ARDC. Requests for information should go to ARDC (Project CATE) Andrews Air Force Base, Washington 25,D. C.



PLUG NOZZLE ENGINE in test cell at General Electric's Malta site. Firm has proposed its version for major space applications, plans flight test.

U-CHANNELS IN THRUST CHAMBER DESIGN

THRUST CHAMBER for NASA propellant-test project is fabricated at Solar Aircraft by first racking U-shaped channels on a mandrel.

CHANNEL RACKING is then done with notched clamping devices. Channels are welded together with about 100,000 spot welds.

RIBBON WRAPPING uses about 2650 feet of 0.008 in. stainless steel ribbon. Chamber is brazed, cooled, brazed again.

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Industry Notes

Martin Entering Propulsion Field

Martin's Nuclear Div. reveals following results of its preliminary design work on reactors and propulsion systems for nuclear rockets:

- Graphite reactor with beryllium oxide in its core could give 68,000 lb thrust with a pressure fed system. This would be satisfactory for a Titan second stage.
- Same reactor could be made to give almost 500,000 lb thrust by substituting a pump system.
- In cooperation with Martin-Denver, Nuclear Div. studied reactor and propulsion system charecteristics in size range of rockets to be used as upper stage on Saturn. Results have been reduced to parametric form by IBM techniques and thousands of computer runs.
- Parametric work also covered plug nozzles and standard deLaval nozzles.
- Martin is considering several test sites for future powerplant work.

Next month, Martin concludes design studies on converting British "Princess" into a nuclear seaplane. Nuclear plane would have about same speed as original Princess.

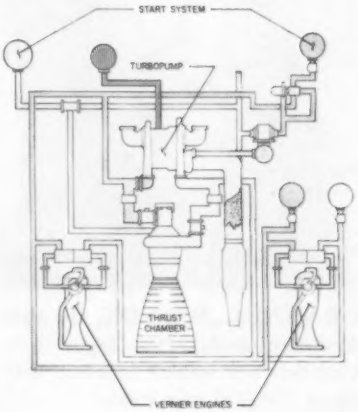
X-1

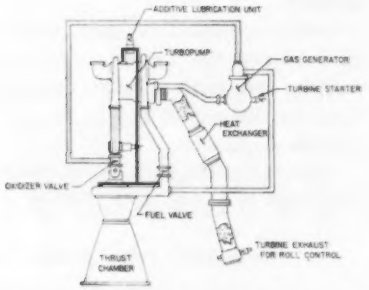
Much of the advanced design work at Rocketdyne centers on the "X" series of experimental rocket engines.

Air Force Program, timed at engine simplification, has proven concepts which have been applied to the Saturn H-1, the 400,000-lb-thrust E-1, and the 1.5-million-lb-thrust F-1 engines.

Rocketdyne reveals that the X-1, first of the series, has been tested successfully with eight moving parts. Initially tested in 1958, X-1 gave valuable data on these concepts improving the original Thor engine:

- Replacing start tank system of Thor with a solid propellant starter unit.





- Improving system for main fuel valve opening. Pneumatic valve sequencing was eliminated; and replaced by a new classified arrangement.
- New concepts of flexible plumbing.
- New lubrication system. High pressure additive to fuel system eliminates former oil pressure system.
- Development of a turbine roll control system and perfection of a method for rapid engine cutoff.

Schematic drawings of conventional (left) and experimental X-1 (above) large liquid propellant rocket engine shows how simplification is being achieved.

The "test-bed" X-1 was operated at thrust level exceeding 200,000 lb. Rocketdyne says the engine proved concepts which "resulted in substantial weight savings."

Automation at Norair

Norair Div. of Northrop Corp. is automating production control. Latest addition to Norair's efficiency drive which has produced PACE (Performance and Cost Evaluation — A&M, December 1958) and Target Cost Program (design stage cost analysis) promises savings in the order of "hundreds of thousands of dollars annually". Savings come from increased production efficiency and lower clerical personnel costs.

Automated Operations Control system gathers production control data such as production orders (30,000 daily), planning change notices, and shortages. Data had been fed into 97 transmitters located at key locations scattered through Norair Production shops. Cost of the system is estimated at $250,000 excluding training personnel and installation.

Information from the Friden Corp. transmitters is punched out on paper tape, in three recording centers, for transfer to the Norair Computing and Datamation center. There, the paper tape is converted to punched cards for recording on magnetic tape for processing in an IBM 704 computer. The computer rapidly processes the data and relays the results back to magnetic tape. This tape is fed into a high speed printer to emerge in report form. Data processing with the IBM 704 takes place in what was computer "down time" occupying about six hours after midnight each day.

The production day starts with a full report on zone shortages, production order status, shop loading, disposition of labor, and completion, etc. Direct savings from the reports are estimated at more than 425 man hours daily.

The bulk of hand processed paper work eliminated by the system is estimated at two boxcar loads annually.

PAPERWORK BOTTLENECK is broken by computer (IBM 704) setup in Norair's system.

New Altitude Chamber at Aerojet

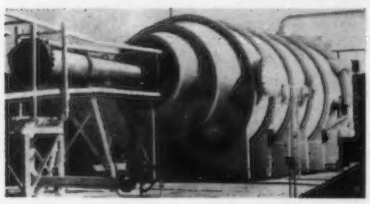
Large solid rocket engines are being tested in a new Aerojet-General facility which duplicates ICBM flight environments.

Located at Aerojet's solid rocket plant near Sacramento, this altitude chamber works on a unique pressure recovery system to maintain simulated altitudes of 100,000 ft.

Rocket motor is mounted within plenum chamber. Vessel is then pumped to vacuum of 100 microns. After the rocket is fired in this simulated altitude, a lightweight cover is discharged from the end of the diffuser. Ejector action of the rocket exhaust then supplies pumping to maintain the reduced pressure.

(In illustration, tube jutting from chamber is escape valve for the hot gases generated during firing.)

Facility was designed and built by FluiDyne Engineering Corp., Minneapolis. It can be adjusted to various altitudes for testing plug nozzles. Aerojet is working on propulsion systems for Minuteman, Polaris, Scout, new solid fueled rockets to be built in sections, and other missiles.



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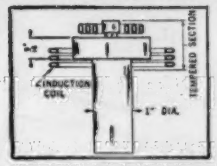
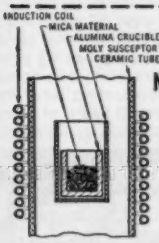
Lepel induction heating equipment represents the most advanced thought in the field of electronics . . . the most practical and efficient source of heat developed for numerous industrial applications. You are invited to send samples of work with specifications. Our engineers will process and return the completed job with full data and recommendations without cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS



Punch Heads Selectively Tempered

Diagram shows arrangement for selectively tempering heads of alloy steel punches. The use of a combination type solenoid and pancake induction coil reduces hardness from Rc 55/56 to Rc 41/44, improving resistance to brittle fracture at the head of the punch. In this case a heating cycle of 55 seconds provides uniform tempering. A multiple position fixture, processing 4 pieces at one time, speeds up production.



Heating Non-Conducting Materials To High Temperatures

Laboratory analyses frequently require heating of non-conducting materials to temperatures of 3,000 to 3,500° F. in vacuum or special atmosphere. This can be accomplished by induction heating with the aid of a metal susceptor. Diagram shows the fusion of mica samples in an alumina crucible, using molybdenum susceptor. A ceramic tube surrounding the susceptor isolates the work for fusion in a vacuum. The molybdenum susceptor is heated by induction, which in turn, heats the crucible by radiation.

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Electronic Tube Generators from 1 Kw to 100 Kw
Spark Gap Converters from 2 Kw to 30 Kw

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AIR He N

COMPRESSION to

12,000 psi

...discharge capacities to 150 scfm

with

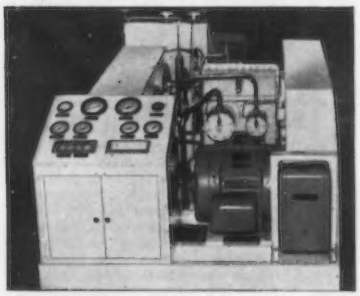
CARDAIR
CENTRAL COMPRESSION SYSTEMS

New Technical Data and Catalog. See offer below.

Cardair Central Compression Systems (completely packaged, semi-portable)—are today handling air and a variety of gases—helium, nitrogen, argon, etc.—at pressures ranging from 4,000 to 12,000 psi with discharge capacities from 50 to 150 scfm. Even hydrogen is being safely compressed to elevated pressures.

Systems can be provided from stock with *guaranteed* purification of delivered gas to —100°F. dew point and less than 4 ppm oil content. Specially engineered systems to meet your particular requirements can be supplied from standard components.

This performance is *demonstrated* by exacting rocket and missile service and continuously growing use by prime contractors, suppliers of missile components and controls, and testing laboratories. It is *backed* by over 20 years of compressor design and application experience.



Model PB-CCS—*One of a wide selection of systems* 4-stage air-cooled Compression System—Pressure Range: 6,000—12,000 psig—Induction: 65 to 135 psig—Capacity: 75 scfm N_2 and Air; 70 scfm He—Guaranteed Gas Purity: —100°F. Dew Point, less than 4 ppm oil content.

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Industry Notes

A2F-1 Instrument Pack

Cockpit display in Navy's forthcoming Grumman A2F-1 will allow pilots to scan and compare engine speed, fuel flow rate and exhaust gas temperature at a single glance.

Data is presented via white vertical-moving columns. Quick data absorption by pilot is necessary because missile-launching A2F-1 is designed to evade radar detection by hugging the earth's contours.

Internal design of the vertical indicators uses an endless sprocket-driven tape. Transistorized, servo-driven, null-balance measuring circuits are used in all three sections.

One-inch dials below the indicators present oil pressure and power trim for each engine.

Instrument display was designed and built by General Electric in cooperation with Grumman.

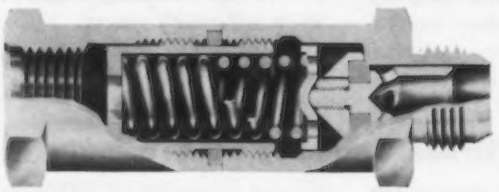
X-15 Plastic Fuselage

A Santa Monica firm, Chemold Co., press-molded a full-scale plastic model of the X-15 fuselage in 13 days.

Plastic job was ordered by the North American Aviation Model Shop.

Molding was done in sections: a straight cylindrical section had 56-in. diam and 28 ft length.

CIRCLE SEAL
RELIEF VALVES *for...*



CLOSED PRESSURIZED SYSTEMS

AIRCRAFT

MISSILES

TEST EQUIPMENT

ZERO LEAKAGE AT OPERATING PRESSURES

Where unfailing relief valve performance is an absolute necessity... exacting CIRCLE SEAL 5100 Series valves provide the one perfect answer for critical service requirements. Each valve incorporates the scientific principles and exacting manufacturing methods that have made Circle Seal valves superior examples of the valve maker's art. Each Circle Seal 5100 Series valve offers these advantages: • **Zero Leakage** • **Dead Tight Reseat** • **Minimum Pressure Rise During Opening** • **Excellent Flow Characteristics** • **Tamper-Proof But Adjustable Settings** • **No Chatter Or Squeal** • **Maintenance-Free Service Life.**

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precision valves

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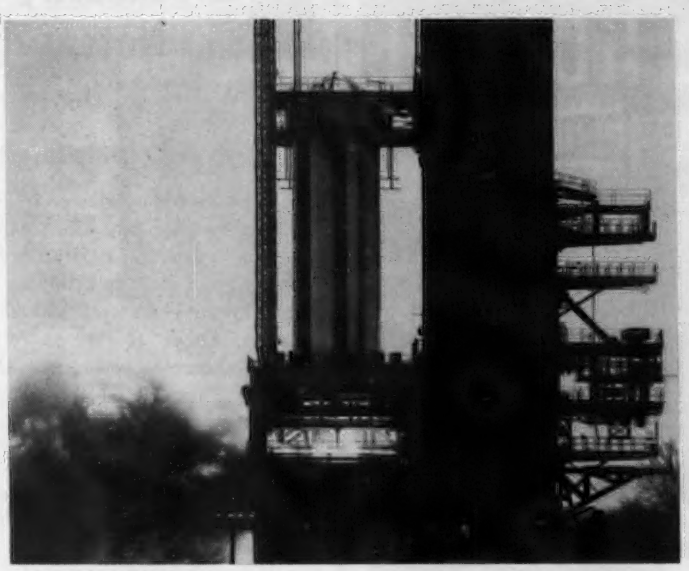
PROPULSION IN PICTURES



SATURN BOOSTER is being static fired at Huntsville. Picture shows four of the eight H-1 engines being tested. They developed over 600,000 lb thrust.

CAPSULE NO. 1 in Mercury program is readied at McDonnell Aircraft for recent shipment to NASA. It will be used to test pilot escape system (note escape rockets on tower).

NEW PLASMA ENGINE at Republic Aviation runs for long periods inside aluminum expansion chamber which simulates outer space conditions.

HAND FORGING for liner of Mach 6 wind tunnel nozzle is finish-machined at Douglas Aircraft. It weighs 8230 lb., will serve as core for nickel shell.

LINEUP of thrust chambers at Rocketdyne comprises (from left), those for Redstone, Jupiter, Atlas sustainer, Thor, and 400,000-lb-thrust E-1 engine now being developed.

BEST WAY TO SEAL HOLES!
LEE PLUG
Simply place plug in reamed hole. Drive in tapered pin until ends are flush. Controlled expansion causes grooves to "bite" into casting, assures a bone dry seal that withstands pressures up to 40,000 psi. Now widely used on aircraft and missiles, and for pumps, servo valves, regulators, etc.
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LEE COMPANY
OLD SAYBROOK CONN
WRITE TODAY FOR COMPLETE ENGINEERING DATA

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MISSILES
BREATHE TOO
YOU KNOW...
...that's why major missile manufacturers specify MIDGET LOUVERS
In seven sizes to meet your needs — one inch through six inches. Available in chrome, aluminum and copper rustproof finish ... installs easily and quickly. Write for our catalogue sheet.
"REGULAR" —with screen and all-weather deflector.
"LD"—screened for interior and protected exterior locations.
MIDGET LOUVER COMPANY
6 Wall Street • Norwalk, Conn.

Circle 39 on Inquiry Card

Industry Notes

R & D Briefs

Tiros controls perfected by RCA included two weights which extended from payload on separation from third stage. Before dropping off, these slowed Tiros from 120 rpm to 12 rpm. Other weights on vertical rods "absorb" wobbling. Nine miniature rockets inside payload increase spinning if needed.

Terrain-avoidance system has been developed by Cornell Aeronautical Laboratory for Wright Air Development Div. Automatic system is now being flight tested.

Heat and noise effects on modern aircraft will be studied in two labs planned by Columbus Div., North American Aviation.

Ground-handling temperature and shock monitoring system for solid propellant missiles is now being offered to industry by Avien Inc.

Aerodynamic deceleration at high mach and altitude is being studied at Cook Electric Co. under Air Force contract.

Launch site evaluation study by Food Machinery and Chemical Corp. aims at showing most economical facilities for a multi-user space vehicle launching complex at Point Arguello, Calif.

Mirror blank measuring 37 in. diam., weighing 450 lb., and 5½ in. thick has been produced by Corning Glass Works. Largest fused silica mirror ever made, it will serve as primary reflective piece in 36 in. telescope to be carried 80,000 ft. high in Project Stratoscope II.

Solid propellant gas generator developed by Rocketdyne features a boost disc of ammonium nitrate cemented to the starting end of the main propellant charge. Disc provides power for starting the hydraulic and electrical system turbines in missiles.

NEW

DEEP-ETCH

MATERIAL FOR CHEMICAL MILLING

Kodak Metal-Etch Resist . . . speeds up, simplifies, opens new chemical milling applications

This photo sensitive resist ends time-consuming handwork, allows close-limit accuracy in deep-etch weight reduction and parts manufacture. Also reproduces fine-line detail as in plating, dial and nameplate making. Withstands acids, alkalies, electrolytic fluids . . . adheres well to aluminum, titanium, magnesium, stainless and other alloy steels. Makes volume production possible because of its high stability, strict uniformity. Send for detailed brochure: *Etching, Chemical Milling & Plating with Kodak Metal-Etch Resist.*

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Kodak

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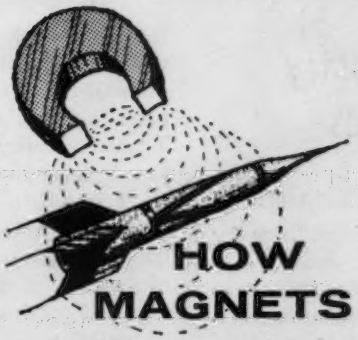
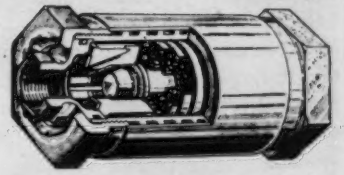


HOW MAGNETS help keep missiles and aircraft flying

FERRO FILTER®

Magnetic Separators



protect fluid power systems of missiles and aircraft by removing even microscopic ferrous particles that can jam delicate, precision-made, hydraulic equipment. Shown above: Model PX-2; dry weight only 3 lbs; 3000 psi working pressure; tapped for ½" tube connection, AND-10050.

Write for BULLETIN HP

S. G. FRANTZ CO., Inc.

385 Kline Ave. at Brunswick Pike

P. O. Box 1138 Trenton 6, N. J.

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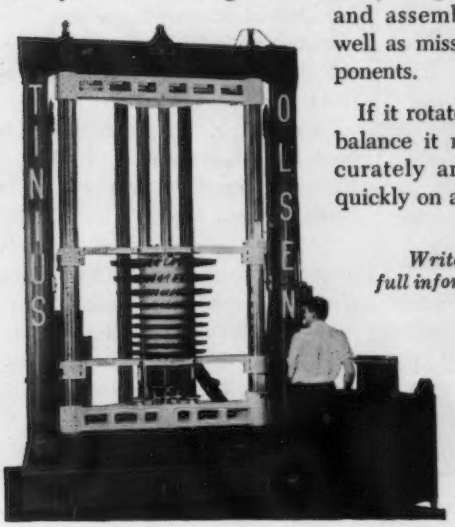
BALANCING JET ENGINES ?

Tinius Olsen offers the most complete line of static *and* dynamic balancing machines for jet engine stages and assemblies, as well as missile components.



If it rotates, you'll balance it more accurately and more quickly on an Olsen.

Write for full information.

TINIUS OLSEN
Testing Machine Co.
2210 Easton Rd. • Willow Grove, Pa.

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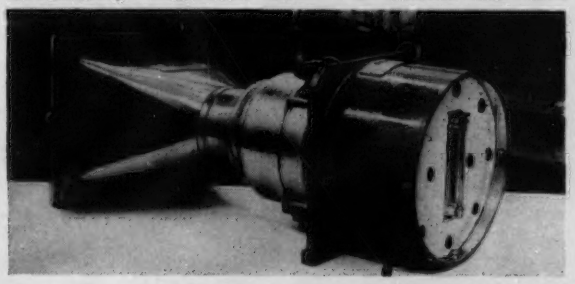
EASIER, FASTER WAY TO SAMPLE AIR



STAPLEX HI-VOLUME AIR SAMPLER

Accurate to 1/100th micron

This is the same air sampler originally developed by the New York Office of the Atomic Energy Commission. Weighs only 10 pounds. Ruggedly built. Fully portable. Yet, it does in 10 minutes what formerly took 36 hours.

The Staplex samples huge volumes of air by passing it through filter paper 4" in diameter. Special adapters are available for 6x9" and 12x12" filters. A turbine-type blower, *designed for continuous operation*, draws in air at speeds up to 70 C.F.M., making it ideal for measuring all types of airborne particulate matter, indoors or out.

Staplex Air Samplers are being used every day to solve the needs of such companies as: Convair, Curtiss-Wright, Lockheed Aircraft, North American Aviation, Pratt & Whitney, Glenn L. Martin and others. Tell us about *your* air sampling problem.

Available in 110V or 220V AC or DC models; 24V DC. $136.50, f.o.b. Brooklyn, New York.

WRITE TODAY FOR NEW BROCHURE

The Staplex Co., Air Sampler Div., 782 Fifth Avenue, Brooklyn 32, N. Y.

Send me complete information on the Staplex Air Sampler.

NAME_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Circle 44 on Inquiry Card

Industry Notes

Production Techniques

Solid propellant ingredients for Polaris are being continuously mixed in small quantities of 20 to 25 lb. This new process at Aerojet-General's Solid Rocket Plant is called superior to former mixing in batches of about 2200 lb.

Computer control of servo system testing at Douglas Aircraft has reportedly sliced testing time from 90 minutes to three minutes per system.

Data acquisition system now at Allegany Ballistics Laboratory makes 167 simultaneous test measurements of solid-fuel rocket motors. System was built by Minneapolis-Honeywell, also supplying a larger system to Hercules Powder's Bacchus, Utah, propellant plant.

"Resonance bending" is being employed to determine fatigue life of metal pipe. Technique, called five times as fast as present cyclic bending methods, may eventually be used to test piping for space travel. Tests, at Tube Turns Div. Chemetron Corp., start pipes vibrating by spinning eccentric weights with an electric motor. Cycles reach several thousand per minute.

Powerplant production for Corporal missiles at Ryan Aeronautical includes drilling the stainless steel rocket head with dozens of .002-in. diam. holes. Through these, jets of fuel and oxidizer spurt and meet at exact distance from head. Ryan final-tests the rockets by sending two tons of filtered water per minute through them to measure flow rates and pressures.

"Spike Power Welding," new control principle for resistance welding is being field-tested by Robotron Corp. System uses smaller transformers than usual.

Brazing techniques that produce clean, bright, homogeneous joints of maximum density and high strength are available to you on a commercial basis. Ipsen vacuum heat treating produces superior physical and metallurgical properties.

Heat treating of stainless steel is also carried out in commercial quantities with Ipsen vacuum furnaces operating at temperatures to 2600° F, and with forced convection cooling!

Ipsenlab of Rockford has served industry for many years with the most modern metallurgical laboratory facilities for pilot or production runs. Call WOodland 5-8788 in Rockford, or write to let us know how we might serve you.

Ipsenlab OF ROCKFORD, INC.

2125 KISHWAUKEE STREET · ROCKFORD, ILLINOIS

New Facilities

National Research Corp. announces establishment of a new Space Vacuum Laboratory in Cambridge, Mass. to provide ultra-high-vacuum testing services for missile and space vehicle programs. Facilities will ultimately reproduce vacuums encountered at orbit altitudes above 500 miles.

Rocketdyne is occupying a new propulsion-research center in Canoga Park. Building was formerly occupied by Atomics International, which is relocating in the city.

NASA's George C. Marshall Space Flight Center begins authorized operation at Huntsville on July 1.

Lockheed Missiles and Space Div. is anchoring Polaris missiles in a steel-concrete test stand at its Santa Cruz, Calif. test base. Steel struts lock on a collar around the missile. Hydraulically-controlled, they permit longitudinal, lateral, pitch and yaw motion, simulating missile launch dynamics.

Propulsion Test Facilities, Div. of MB Electronics, is designing a space simulation laboratory for NASA's Goddard Space Flight Center now under construction.

Unified Science Associates have established facilities for basic research and development at Pasadena, Calif.

Lear, Inc. schedules groundbreaking this month on 30,000 sq. ft. corporate executive office in Santa Monica.

Linde Co. breaks ground this month in North Haven, Conn. on a plant to make its Flame-Plating process available to East Coast industry.

Sylvania Electronic Systems will build a new Applied Research Laboratory and a new headquarters building in Waltham, Mass.

Linde Co. has installed a 13-ton-capacity liquid hydrogen storage sphere at its liquid hydrogen plant being built at Torrance, Calif.

Ling-Altec Electronics Co. has expanded its Anaheim, Calif., plant by 65,000 sq. ft.

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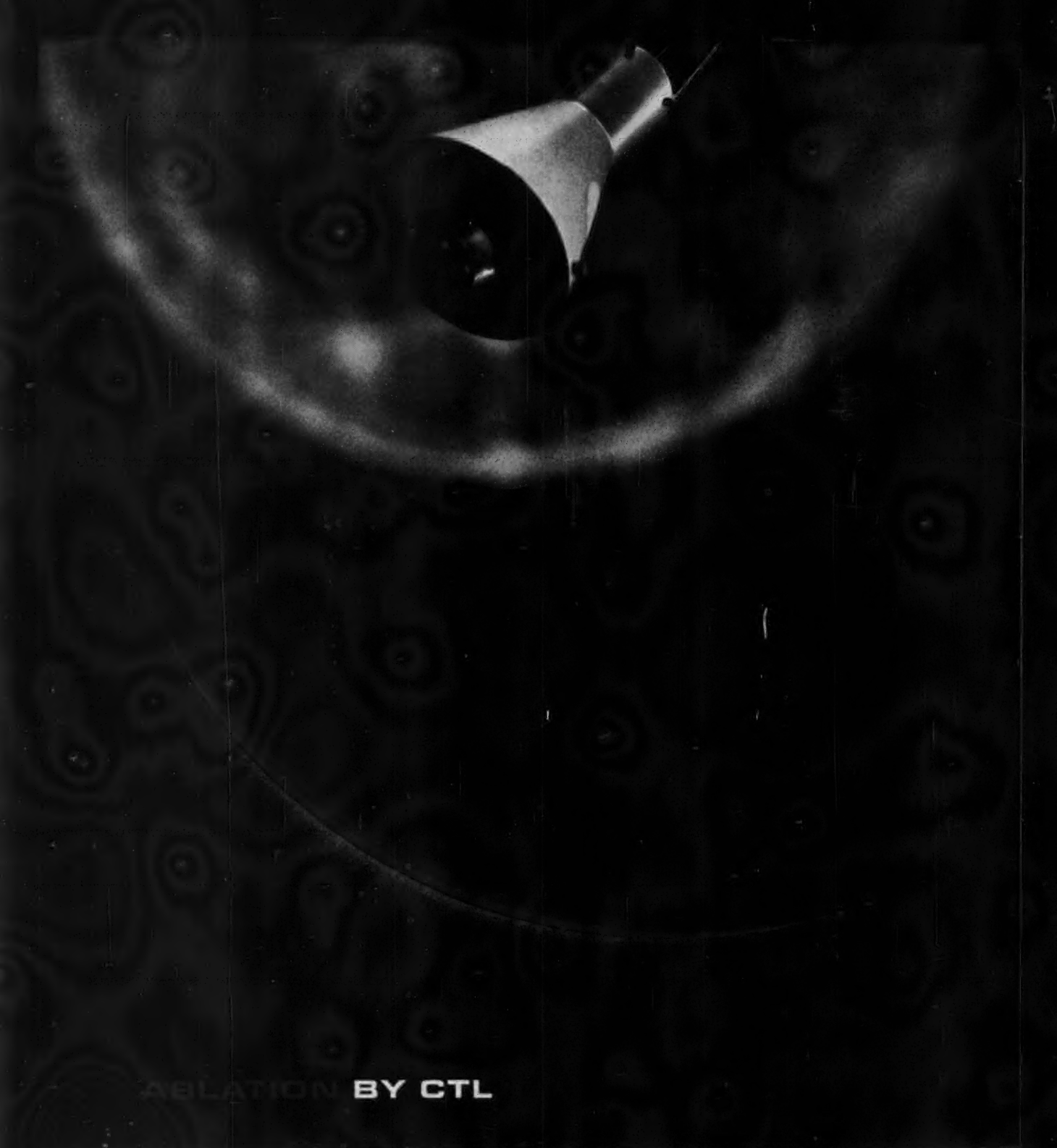
Circle 46 on Inquiry Card →



ABLATION BY CTL

Heat dissipation by the gradual and controlled separation of matter—an area of intense research at CTL for several years. If heat flux on any surface in your design ranges from 50 btu/ft² sec to 50,000 btu/ft² sec, benefit from CTL's work with reinforced plastic fabrications. Development of high temperature resins plus sophisticated reinforcement fiber orientation has made it possible for CTL to provide effective, low-weight fabrication —expansion cones of Minuteman, the nose of the Jupiter, the face of the Mercury. Find out how CTL can assist with your heat insulation problems. Request Bulletin 160.

CTL 1243 GLENDALE-MILFORD ROAD, CINCINNATI 15, OHIO
A Division of Studebaker-Packard Corporation

Industry Notes

ANTI-ICING systems on Convair 600 are inside six-ft.-diam. pods which utilize bleed air from CJ-805-23 engines.

Business Moves

Bell Aircraft Corp. and Nord-Aviation, S.A. of France have signed an agreement giving Bell an option for U.S. manufacturing rights on Nord's CT-41 and CT-20 target missiles.

Republic Aviation Corp. will acquire substantial minority interest in the Royal Netherlands Aircraft Factories Fokker, Amsterdam. Anticipated result: mutual repair and overhaul for F-84's and F-105's; cooperation on weapons systems for NATO forces.

Acton Laboratories has formed a new Space Instrumentation Div. for work on packaged rocket and satellite precision instrumentation.

Hughes Aircraft now has a Microwave Tube Div. and a Vacuum Tube Products Div., both in Los Angeles.

Precision Rubber Products Co. is setting up two new direct factory branches, at Kenilworth, N.J. and Wellesley, Mass.

Bausch & Lomb Optical Co. now has a separate Military Products Division.

Lockheed Electronics Co. will locate future headquarters on a recently purchased 212-acre site near Princeton, N.J.

The CompuDyne Corp. has signed an acquisition agreement with American Measurement & Control.

Trident Corp., recently formed in Boston as subsidiary of Avien Inc., will conduct research and development of undersea detection systems.

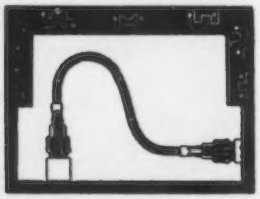
General Electric's new Electronic and Flight Systems Group includes its Defense Electronics Div., Syracuse, Electronic Components Div., Owensboro, Ky., Flight Propulsion Div. and Aircraft Nuclear Propulsion Dept., Cincinnati.

Chromalloy Corp., White Plains, N. Y., has acquired Sintercast Corp. of America, Yonkers, N. Y.

(Advertisement)

FLEXIBLE SHAFTS

Handle wide variety of control applications.



The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the power drive flexible shaft which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the remote control flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The remote control shaft provides for both rotation and reciprocation, such as the opening and closing of a valve. • • • For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

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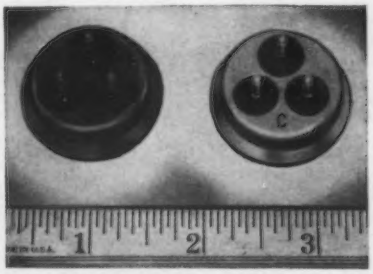

FUSED GLASS AND METAL MISSILE PARTS CLEANED QUICKLY AND WITHOUT DAMAGE TO GLASS GLAZE
with **VAPOR BLAST**

Liquid Honing*

Vapor Blast Liquid Honing process cleans metals fused to glass without removing glaze or damaging the glass.

Yet the metal parts are thoroughly cleaned, burrs removed, in shortest possible time.

Bring or send parts for test cleaning. No obligation.

*Liquid Honing and Vapor Blast are trademarks.

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V-B VAPOR BLAST MILWAUKEE WISCONSIN

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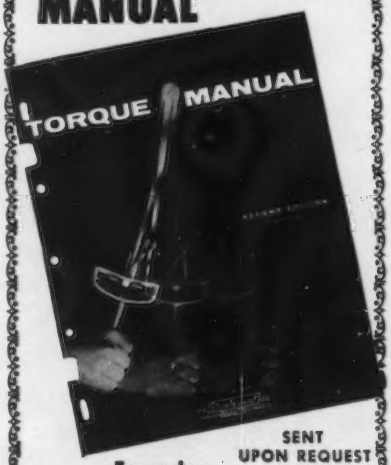
"TORQUE WRENCH" MANUAL



SENT UPON REQUEST

Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

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Over 2400 manufacturing concerns are now operating in Metropolitan Miami!

Electronics, aircraft and missile manufacturers can be sure of supplementary and sub-contracting facilities in this growth area. This, combined with a huge supply of skilled labor, can mean a profitable plant location for *your* firm.

SEND FOR 300 PAGE SURVEY OF THIS DYNAMIC AREA

This important study will be mailed to you, in strictest confidence, if you write, on your letterhead, to the address listed below.

Richard U. Welsh, Director
Dade County Development Department
345 Northeast Second Avenue
Miami 32, Florida
An Agency of the Metropolitan Miami Government

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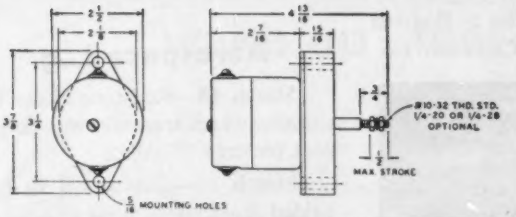
D. C. SOLENOIDS



Synchro-Start **SL SERIES SOLENOIDS**

are for operating engine throttles, fuel pump racks, chokes, etc. and are available with several variations. Other models in 1" and 1½" strokes.

VOLTAGES (D. C. Only)
6V. 12V. 24V. 32V.

CURRENT DRAW (Pulling)
55A. 35A. 15A. 12A.

CURRENT DRAW (Holding)
1.6A. .8A. .4A. .3A.

DUTY
Continuous

CYCLES
Not to exceed 6 per minute

PULL
Approximately 10 lbs. over ½" stroke

WEIGHT
2¼ pounds

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE • SKOKIE, ILL.

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Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

IDEAL INDUSTRIES, Inc.
1390-E Park Avenue, Sycamore, Ill.
Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."
Name_____
Company_____
Address_____
City_____ Zone____ State_____

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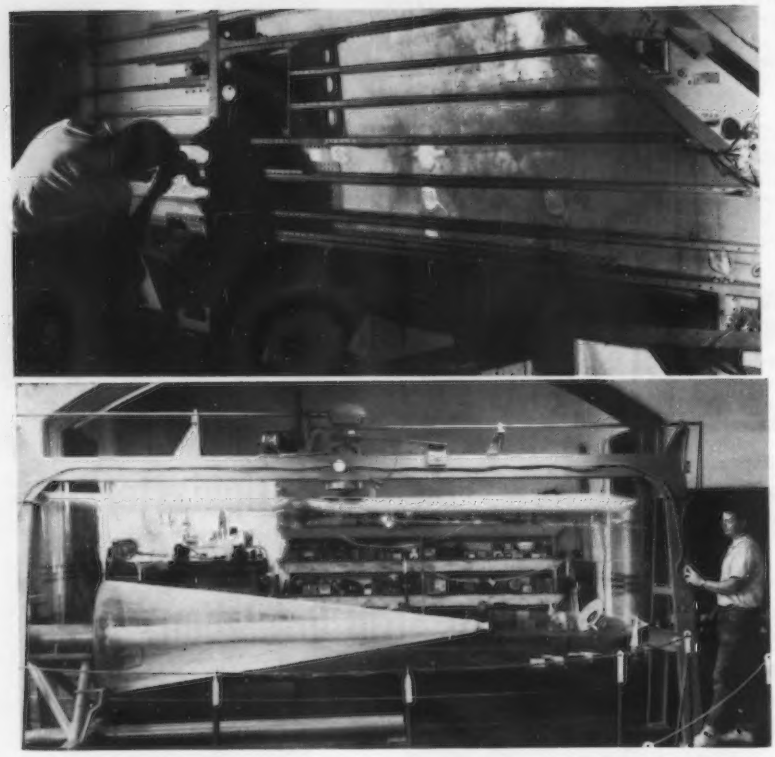
Industry Notes

Birth of a Bomarc

FINAL ASSEMBLY inspector examines IM-99A wing.



LONGO WINDER applies the longitudinal glass fibres to a Bomarc radome at the Vashon Island plant of the Brunswick-Balke-Collander Co.

AFTER WELDING and heat-treating, Bomarc tank is made size perfect by explosive forming in a water-filled die.

FINAL ASSEMBLY at Boeing-Seattle. Firm's producibility advances saved 52 hrs. flow time per missile, reduced space 67 per cent.

Contracts

Grumman Aircraft—$128-million for production of Navy aircraft. This comprises $52.3-million for A2F-1 carrier-based attack planes, $47-million for W2F-1 early warning planes, $28.7-million for S2F-3 Trackers for anti-submarine warfare.

Westinghouse Electric — $38,-500,000 from the Navy to develop and produce prototype of the long-range radar to be used on "Typhon" ship-based defense system.

Convair—$5,500,000 for first year of development of Mauler battlefield air-defense missile.

Northrop Corp., Nortronics Div. —$20,883,800 for follow-on production of Hawk missile airframe items; $1,764,000 for Hawk R & D through December.

Avco Corp., Lycoming Div. — $14,234,460 to produce T53 gas turbines for the Air Force.

Sikorsky Aircraft—$45-million for HSS-2 helicopters and related equipment.

General Electric Co., Small Aircraft Engine Dept. — $8.3 million for J85 jet engines, $5.5-million for T-58 gas turbines.

Aerospace Log

March 15—Redstone ejects TV capsule, which transmits missile-impact pictures 75 miles.

March 16—Corvus makes first guided flight.

March 17—X-15 No. 2 in sixth test goes to 50,000 ft.

March 22—Titan goes 5,000 miles second time.

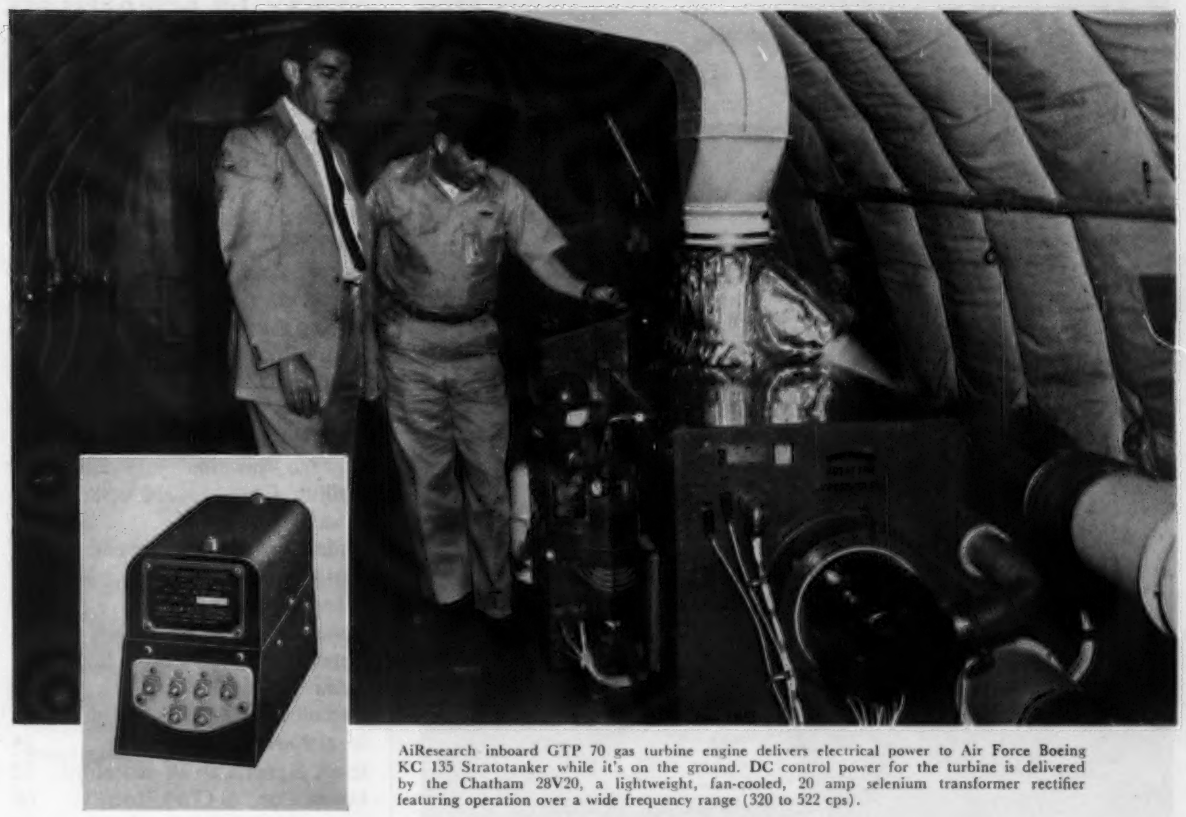
March 23 — F-106 goes nonstop across U. S.

March 23—Juno II fails to orbit Explorer.

March 27 — Polaris begins launchings to test ignition, guidance.

April 1—Tiros I orbited. This first TV weather satellite begins transmitting pictures of cloud cover.

April 13—Transit I navigational satellite orbited by Thor-Able-Star with start-stop ability.



AiResearch inboard GTP 70 gas turbine engine delivers electrical power to Air Force Boeing KC 135 Stratotanker while it's on the ground. DC control power for the turbine is delivered by the Chatham 28V20, a lightweight, fan-cooled, 20 amp selenium transformer rectifier featuring operation over a wide frequency range (320 to 522 cps).

CHATHAM T-R helps AiResearch "wake up" fuel-ferrying jet tanker

This is the AiResearch inboard gas turbine engine. It supplies the space age power which operates instruments, lights, radio, radar and cabin heaters on the Air Force Boeing KC 135 Stratotanker while it's on the ground.

AiResearch specifies the Chatham 28V20 AC to DC transformer rectifier to assist the turbine in the ground warm-up job that helps the tanker streak away with split-second efficiency on its refueling rendezvous with thirsty, far-from-home jets.

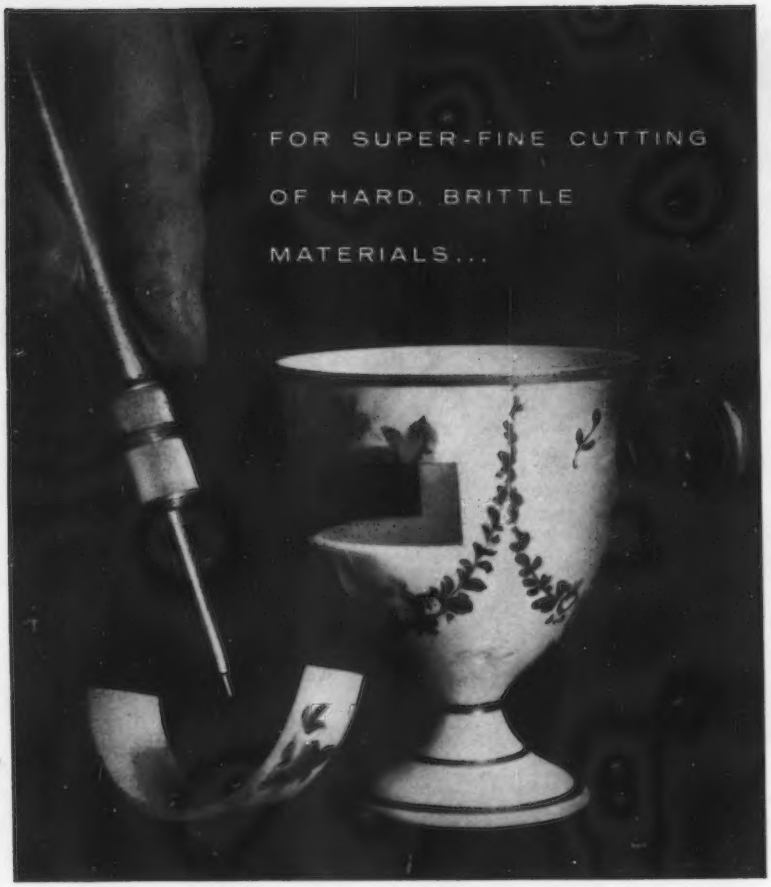
The Chatham 28V20 delivers DC power to the turbine generator for all control functions. The converter also supplies the power to recharge the turbine engine battery, which supplies the starting power for the AiResearch equipment.

Satisfying rigid specifications and critical performance levels for missiles, jet aircraft and commercial airliners is second nature to Chatham. That's because Chatham maintains complete control of every step in the production of power conversion equipment. For example, by producing its own solid-state elements — whether silicon, germanium or selenium — Chatham designers are not limited by the "specs" of commercially available components. By strictly controlling component dimensions and reliability, Chatham keeps size and weight to a minimum, while satisfying precise electrical requirements.

Send for Chatham brochure T-26 which shows many existing transformer-rectifier units. Or, outline your needs and Chatham will recommend an original design to do the best job for you. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N. J. TWX:NK193.

CHATHAM . . . *world's leading supplier of airborne power conversion equipment.*

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.



THE S. S. White® Industrial Airbrasive® Unit

We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!...printed circuits...shaping and drilling of germanium and other crystals...deburring fine needles...cleaning off oxide coatings...wire-stripping potentiometers...engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

SEND FOR BULLETIN 5705A...complete information.

S. S. WHITE INDUSTRIAL DIVISION
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

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and

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USE FREE READER SERVICE CARDS

Postcard valid 8 weeks only. After that use own letterhead fully describing item wanted. **MAY, 1960**

Please send further information on items circled below.

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21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
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161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180

For the following numbers pertaining to recruitment please use home address.

181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220

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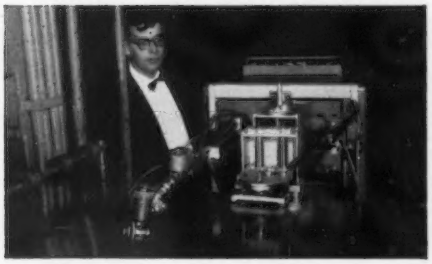

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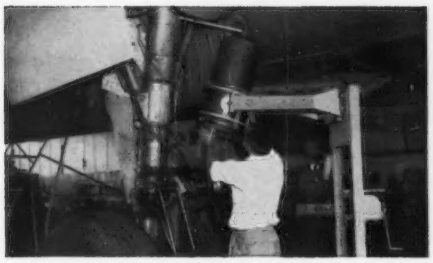

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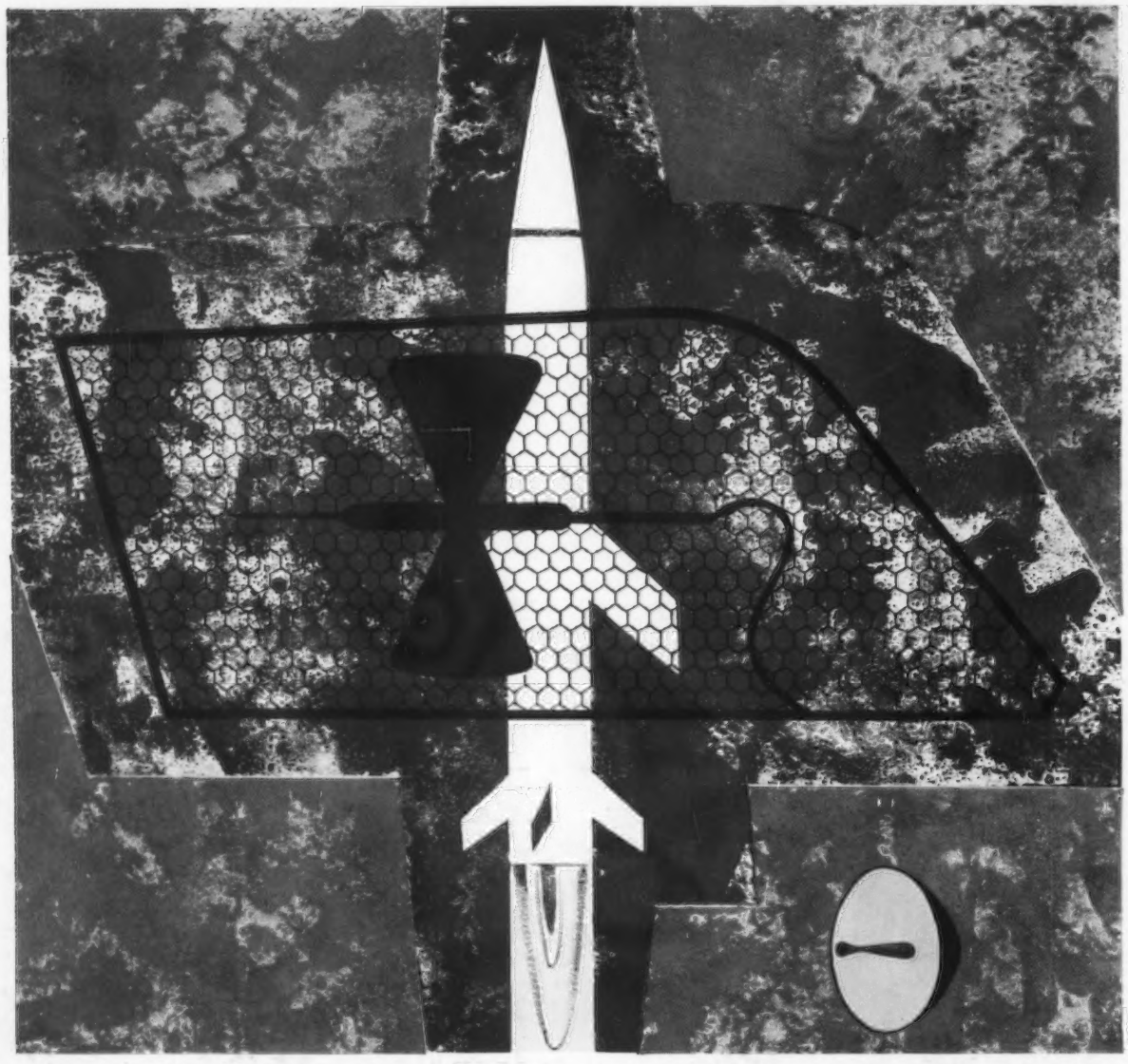

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